A MANUAL OF

MODERN

STEAM LAUNDRY WORK

FOR THE USE OF PRACTICAL LAUNDERERS, FINISHERS, MANUFACTURERS, STUDENTS, AND ALL INTERESTED IN CHEMICO-TEXTILE INDUSTRIES.

BY

ELLIS CLAYTON,

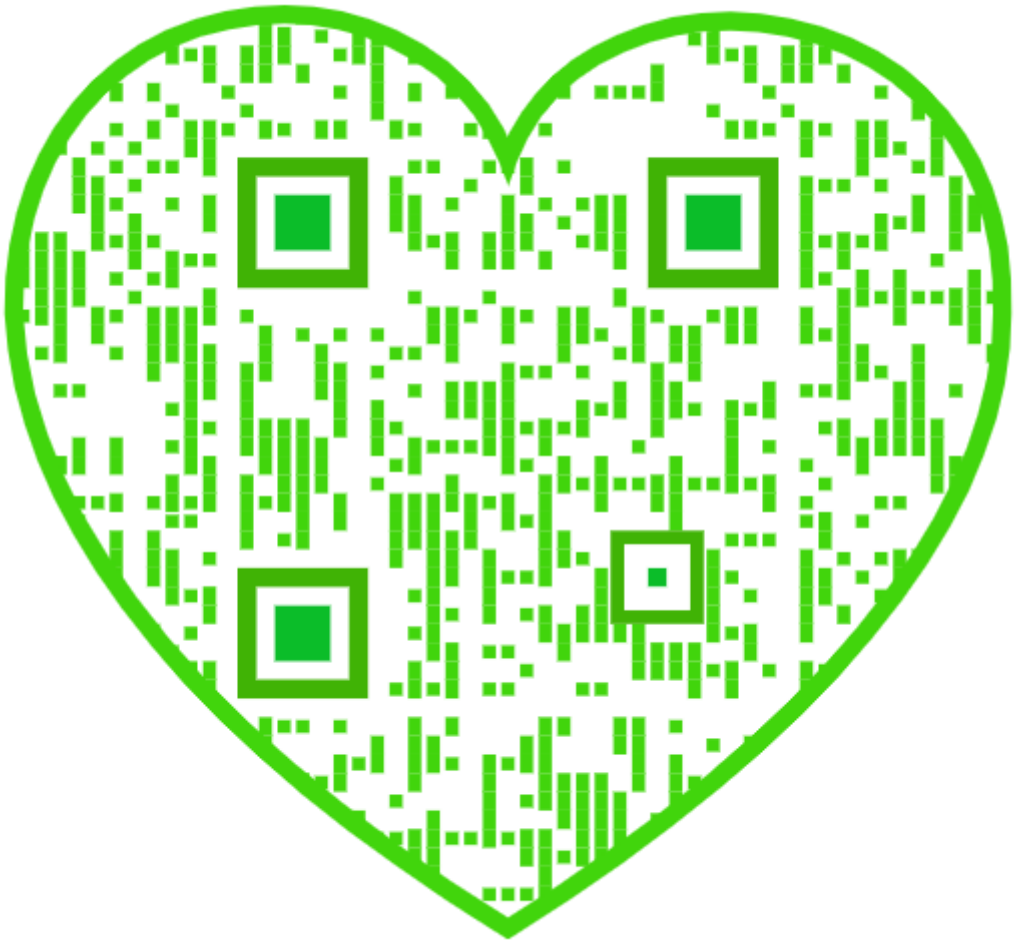
LECTURER ON BLEACHING, DYEING, AND FINISHING AT THE MUNICIPAL TECHNICAL INSTITUTE, BELFAST; FELLOW OF THE CHEMICAL SOCIETY; MEMBER OF THE SOCIETY OF CHEMICAL INDUSTRY; MEMBER OF THE SOCIETY OF DYERS AND COLOURISTS; SOME TIME TEXTILE AND DYERS' CHEMIST AT THE SALTAIRE MILLS.

WITH ONE HUNDRED AND THIRTY-NINE ILLUSTRATIONS.

LONDON:

SIMPKIN, MARSHALL, HAMILTON, KENT & CO., LIMITED.

[*All Rights Reserved.*]



MARSDEN AND CO., LTD.
PRINTERS,
MANCHESTER

PREFACE.

It has often been stated by various authorities that the Laundering Industry ranks in importance second or third only to the Cotton Trade; and yet, in spite of its magnitude, the available Technical Literature on the subject is of a very scanty nature. The latter statement would appear to indicate that this branch of Textile Industry has not received as much attention by technologists as its importance merits, though there is reason to believe that a wider dissemination of exact information concerning the methods in vogue, and the machinery employed, will serve to show the great field for invention and research that is here offered

Laundering Processes have been evolved almost entirely by rule of thumb, but it is worthy of note that, in the best conducted modern works, they are in accord with scientific principles. It will, of course, be obvious that such a mode of evolution of a vast and widely scattered industry would inevitably give rise to numerous modifications of the main operations, irrespective of the nature and condition of the goods, and, at the present time, there are no universally recognised standard processes for the treatment of any particular class of articles.

The object of the following work is to supply a Handbook of Steam Laundering Practice in all its Branches, and the Principles upon which it depends.

It was originally intended to issue an elementary work on the Technology of Laundry Work, but a closer study of the various methods employed in different works to obtain practically the same results, as well as other considerations, afforded ample evidence that there was a strong demand for a book dealing systematically with the best Modern Practice as well as the chief underlying Principles. It is hoped, therefore, that the attempt made in the following pages to satisfy this demand will prove of service to all interested in the progress of the industry. A considerable portion of the text is based on a series

of Lectures delivered by the author in the Municipal Technical Institute, Belfast, a few years ago, before the launderers of that city.

In the Chapter devoted to Materials, concise accounts only of a large number of substances have been given, but substances of great interest or importance from a launderer's standpoint, have been more fully considered.

The Machinery Section has been made as complete as possible in the space at disposal, and diagrammatic views have been included wherever considered necessary.

The interest taken in the progress of the book by many laundry proprietors and managers, their kindness in supplying useful details and granting the author facilities for the purpose of enabling him to gain a practical knowledge of the industry, have been sources of the greatest encouragement.

It is his pleasant duty, therefore, to acknowledge his deep obligation to all who have assisted, either directly or indirectly, in building up the Work, and to the various Engineering Firms who have kindly lent Blocks illustrating modern machines.

The author's warmest thanks are due to Messrs. Charles and Dixon Ross, for supplying special information of a practical nature, and for their kindness in reading over a portion of the Chapter dealing with Mechanical Appliances.

Any communications relating to new Machines, Processes, and Materials, or special Apparatus which may have been inadvertently omitted will be highly appreciated, so that the text can be thoroughly revised and the utility of the book increased in the event of a second edition being required.

Belfast, E. C.
September, 1912.

DIRECTOR OF INDUSTRIES
Bengal.

MODERN LAUNDRY WORK.

INTRODUCTION.

By the term **laundry work**, or **laundering**, is meant certain processes of cleansing and finishing wearing apparel and the miscellaneous textile articles of the household. By far the largest proportion of such articles is cleansed with the aid of alkaline detergents, the remainder being subjected to a process termed dry-cleaning, which involves the employment of volatile solvents. Dry-cleaning is an industry quite distinct from laundry work, and is usually carried on in conjunction with dyeing. Work of this nature is highly specialised, and the underlying principles have little in common with those that appertain to laundry work. We may define the latter term, therefore, as any process which involves the cleansing of detached textile articles with alkaline detergents, and their subsequent after-treatment in order to impart the requisite "finish."

Laundry processes differ in many important respects from those carried on in the allied industry of bleaching and finishing, although the principles of both industries are not widely dissimilar. The chief points of difference are as follows:—In the first place, laundry work involves the cleansing and re-dressing of small detached articles, which have become soiled either by use or during manufacture; in the second place, the machinery employed is of necessity quite different from cloth bleaching and finishing machinery; and in the third place, white and coloured plain and embroidered articles, made from various textile fibres, are cleansed and finished, whereas in the majority of bleach and finishing works only raw cotton and linen in the form of yarn or long pieces of cloth are dealt with. Further, in the bleaching of raw fibres, the chief object is to get rid of natural impurities, this being achieved by means of a more or less energetic treatment with comparatively strong alkaline detergents, the goods obviously becoming lighter. As a rule artificial dirt acquired during manufacture is only of secondary importance, and offers little resistance towards the liquors employed.

On the other hand, however, the removal of acquired dirt is the chief object of the laundry cleansing process, the accomplishment of which, frequently offers more complex problems than in the bleaching of raw materials, for not only is the dirt of a widely varying nature, but it is often associated with a large amount of starchy matter, and in some cases with the insoluble portions of certain "glazes," while a large proportion of the goods to be treated is made of several folds of cloth, thus resisting the action of the cleansing fluids to a greater or less extent.

Modern laundry work may be classified into the three following divisions, viz. :—1. Domestic Laundry Work. 2. Trade Laundry Work. 3. Laundry Work carried on in Institutions.

1. **Domestic Laundry Work.**—Strictly speaking, the term domestic laundry work, means the kind of work which is still carried on to a considerable extent in town and country dwellings for the purpose of cleansing articles of wear and of the household. The inconveniences arising—principally in town dwellings, where space is often limited—from the operations inseparable from work of this nature have caused the evolution of modern commercial laundries, in which the same kind of work is done, but under healthier conditions, and in most cases with the aid of machinery specially designed to shorten the processes and to dispense with the laborious operations associated with such work when done by hand.

The employment of labour-saving appliances in the domestic laundry—or, in fact, other types of laundries—however, is by no means universal, owing chiefly to economic reasons, and there is still a considerable number of commercial laundries in existence, in which practically the whole of the operations are carried on by hand, hence the term "hand laundries."

The tendency amongst launderers at the present time, however, is to make use of machinery whenever possible, and it appears very probable that commercial laundries in which ordinary domestic work is done by hand, will be gradually displaced by power laundries as the industry becomes more highly organised and developed. Of course, even in fully-equipped establishments there is always a certain amount of work which can only be properly dealt with by hand.

2. **Trade Laundry Work.**—In this branch of the trade two distinct classes of work may be distinguished, viz. :—The laundering of new shirts, collars, cuffs, etc., and the laundering of all kinds of new linen and cotton goods which have not to be heavily starched.

New shirts, collars, and cuffs, commonly termed "new work," are usually cleansed and finished in laundries attached

to the factories in which the goods are manufactured. This statement also applies to the second class of goods, although in many cases such work is carried on in private laundries, to which the goods are despatched by the manufacturers. The term "new work laundry" is often used to indicate a laundry belonging to the first class, and trade laundry is the name usually given to a laundry in which a speciality is made of the cleansing and finishing of plain and embroidered soft-finished goods.

3. **Laundry Work carried on in Institutions.**—The laundry processes carried on in hospitals, workhouses, asylums, etc., are essentially the same as those which are characteristic of domestic laundry practice. In a great many cases, however, the articles to be treated are contaminated with foul matter, blood, and other stains, and not infrequently with disease germs. Hence, the mode of treatment is not only governed by the nature of the goods, but their condition also constitutes an important determining factor.

Various machines are now made in which foul goods can be thoroughly cleansed without handling, while special appliances are also available for disinfecting purposes.

INDEX.

Acid, acetic, 61
„ boric, 96
„ carbolic
„ formic, 61
„ hydrochloric, 62
„ marine, 62
„ muriatic, 62
„ oleic, 33
„ oxalic, 90
„ salicylic, 97
„ sulphuric, 62
„ bath, 234
„ treatment of new embroideries, etc., 327, 332
Acids, fatty, 37
„ free, fatty, 230
Air, humidity of, 264
„ blowers, 280, 166, 190
„ compressed, 280
„ ducts, 168
„ heaters, 163
„ outlets, 169
Albuminous substances, 225, 226, 229, 246
"Alkali-dip," 67, 329
Alkali, free, 36, 229
„ 58 per cent., 42
„ pure, 42
„ refined, 42
Alpaca, 21
American collar factories, prevention of shrinkage of cloth in, 301
American press plant, 195
Ammonia, 48
„ soda process, 43
Ammonium chloride, 103
„ hydroxide, 48
„ phosphate, 103
Amylase, 50
Aniline black marking inks, 299, 302
„ „ stamping paste, 303
Animal fibres, 4
Anthrax spores, effect of chlorine on, 340
„ bacillus, 347
Antichlors, 74. 239
Antiseptics, 90
Apron attachments, 181
„ starchers, 312
Aqueous vapour, 263
Atmosphere, composition of, 266

Ball clip bars, 166
Bacillus, anthrax, 347
Bacillus, coli, 340, 342
„ diptheriæ, 347
„ staphylococcus pyrogenes aureus, 347
„ typhosus, 340
Barley, 50
Basting in collar manufacture, 302
Bast fibres, 13
Bedspreads, ironing, 280
„ cleansing new, 330
Beeswax, 90
Benzene, 98
Benzine, 98
„ soaps, 40
Benzol, 98
Benzoline, 98
Berlin clear starch work, 310
Bicarbonates in water, detection of, 106
Bleaching, 234, 235, 259
„ action of sodium hypochlorite in, 238
„ agents, action of, 64
Bleaching liquor, electrolytic, 67
„ powder, 64
„ „ solution, 233, 235
„ „ stock solution of, 65
„ „ valuation of, 65
„ „ uses of, 66
Bleach vat for woollens, 260-1
Blocking, 185, 191, 276, 277
„ machine, concave iron, 203
„ machines, 186
„ object of, 277
Blood stains, 296
„ „ on disinfected goods, 344
Blouses, cleansing new, 330-1
„ ironing, 280, 288
Blowers, air, 166, 190, 280
Blueing, 234, 235, 239, 329
„ American practice in, 242
„ defects in, 241
Blue, liquid Prussian, 93
„ powdered „ 93
„ Prussian, 92
„ Turnbull's, 93
„ ultramarine, 92
Blues, coal-tar, 93
„ insoluble, 93, 239
„ soluble, 92, 239
Body ironers, 219, 220
„ "linen," washing process for, 249

Boiled starch, 306
,, ,, physical properties of, 319
,, ,, preparation of, 312
,, ,, process, 306, 270, 152
,, ,, work, drying, 267
Boiler scale, 109, 110
Boiling with soap and alkali, 232
Bolts, steam, 290
Borax, 48, 89
Bosom press, hand, 203
,, ,, power, 199
Botany wool, 21
Brax diastase extract, 52
Breakdown, 225, 325
,, ,, alkaline, 226, 228
,, ,, amount of alkali for alkaline, 226
,, ,, malt, 247
,, ,, mode of procedure in, 227
Brimal, 52
Brine, electrolysed, 237
Burner, atmospheric gas, 280
Burners, perforated, 187

Calcium acetate, 234
,, hypochlorite, 235
Carbolic acid, 96
,, ,, as a disinfectant, 341
,, ,, coefficient, Lancet, 341
Carbon dioxide in water, detection of, 106
,, tetrachloride, 99
Cashmere, 21
Caustic soda, 46
,, potash, 47
Cellulose, 8
,, nitrates, 9
Chalk, French, 94, 89
Chardonnet silk, 29, 10
Checking, 221-2
China-clay, 94, 87
,, ,, analyses of, 95
China grass, 19
Clear finish, 88
Chlorides in water, detection of, 106
Chlorine, available, 65
,, bleach, 296, 308
Chloroform, 99
Chlorophyll, 299
Cleaning, dry, I.
Cloth, union, 4
,, used in collar manufacture, 300, 301
Coal-tar blues, 93
,, ,, disinfectants, chemical examination of, 341
Coffee stains, 296
Collar, features of a double, 300
,, etc., manufacture, terms used in, 300
Collar and cuff dampeners, 315-6
,, and cuff shapers, 215
,, ironers, steam heated, 209
,, presses, 192-3
,, shaper, "Heim" double, 217
,, ,, roller, 216
,, ,, tube, 215
Collars, ironing wing, 278
,, shaping double, 278
Coloured goods, washing, 251-2
Colours bleeding in steam disinfector, 344
,, mineral, 239
Compartment washers, 136
Cookers, starch, 312
Cotton, 5.
,, action of chemicals on, 8-12
,, chemical composition of, 8
,, commercial varieties of, 7
,, cloth used in collar manufacture, 301
,, hygroscopic moisture in, 7
,, impurities in raw, 7
,, mercerised, 12
,, seed oil, 5, 230
Covers, ironing pillow, 280
,, ,, cushion, 280
Crystal finish, 88
,, carbonate, 42
Cuff presses, steam, 194
Curtain drying box, 291
,, finishing, 290-3
,, frames, 290-2
,, new, 251
,, tinting, 251
,, truck, "Troy," 292
Curtains, washing processes for, 251-2
Cushion covers, ironing, 280
Cutting out in collar manufacture, 301
Cylinder, "Surgar" inner, 131
,, washers, 122-143
,, ,, sizes of, 123
Cylinders, metal inner, 127

Dampening, 287
,, in boiled starch process, 314
,, machines, 314
,, presses, 288
Dampener, vapour, 287
Dampeners, collar and cuff, 315-6.
,, seam, 212-3
Decoudun, 174-6
,, rollers, 174
,, ,, covering, 176
Decroline, 75
,, removal of stains with, 297, 299
Detergent action of soap, 229-231
Dextrin, 83, 84, 51

Dextrose, 83, 84
Diastase, 50.
Diastofor, 52
Diastatic power, determination of, 54
" Dip alkali," 67
Dipping new embroideries, etc., 328-9, 332
Dirt, insoluble surface, 225
Diseases, infectious, 339
Disinfectants, 338
,, action of liquid, 342
,, proprietary coal-tar, 341
Disinfection, 338
,, definition of, 339
Disinfecting goods in mild cases, 338
,, with chemicals, 339, 340
,, ,, steam; 339
Disinfector, Alliott and Paton, 350
Disinfectors, advantages of current steam, 343
,, current pressure steam, 346
,, Thresh's, 344-350
Disc edge ironer, 211
Domestic laundry work, 2
" Double starch," 306
,, ,, mixtures, 307-8
,, ,, process, 306-310, 270
Dry cleaning, I.
Drying, 221
,, apparatus, 161
,, boiled starch work, 267, 314
,, box for curtains, 291
,, by means of a warm air blast, 164
,, oven, 162
,, practice of, 267
,, principles of, 263
,, systems, 266
,, room, truck compartment, 163
,, rooms, 164, 165
,, ,, air outlets of, 169
,, ,, automatic clips for conveyor, 173
,, ,, conveyor, 170-3
,, ,, supports for goods in, 166
,, ,, horses for, 166
,, woollen goods, 267
Dry-room tumbler, 268
Ducts, air, 168
Dusters, washing process for, 249
Dyes, acid, 235
,, basic, 235
,, coal-tar, 239
Dye stains, 299

Eaves' gas irons, 282
Edge ironers, 211-212
Egg albumen, 23
Electric irons, 282
Electrolyser, Haas and Oettel, 69
Electrolytic apparatus, 69
Embroidered articles, ironing, 290
Embroideries, acid treatment of, 327, 332
,, impurities in hand, 322
,, manufacture of, 321-4
Embroidery, hand, 322
,, machine, 323
,, patterns, perforating machine for, 322
,, ,, printing, 322
,, printing pastes, nature of, 322-3, 327
,, Swiss, 324
Emulsions, soap, 229
Enzymes, 50
,, liquefying, 52
,, saccharifying, 52
Ethane tetrachloride, 100
,, pentachloride, 100
Ethylene, dichloro, 100
,, trichloro, 100
,, tetrachloro, 100

Farina, 79
Fats, saponification of, 31
Fatty acids, 37
Fatty acids, free, 230
Feculose, 86
Feed device, ribbon, 176, 85
Fehling's solution, 55
Felting of woollen goods, 252
Fibres, animal, 4
,, artificial, 28
,, bast, 13
,, commercial textile, 4
,, insoluble carbonates in, 228
,, vegetable, 4
Finish, production of glossy, 272
Finishing, 221, 269
,, bedspreads, sheets, etc., 332
,, curtains, 290
,, new handkerchiefs, etc., 329
,, operations in institutions, 338
,, paste for handkerchiefs, 330
,, silk goods, 293-4
,, woollen goods, 293
Fireproof finishes, permanent, 102
Fireproofing substances, 101
Flannels, grey, 259
Flannel washer, "Ibis," 254-5
,, ,, "Troy," 255-6
,, ,, "Waterleap," 255-6
,, ,, Williamson's, 253
Flat work, 263

Flax, action of chemicals on, 16
,, chemical composition of, 15
,, impurities in raw, 13
,, retting, 13, 14
,, structure and properties of, 15
Flexible cable ironer, 191
Formaldehyde, 96
,, ,, as a disinfectant, 340-2
Formalin, 96
Foul "linen" washing, 335
,, ,, washers, 335-7
French chalk, 94, 89
Frilled goods, ironing, 280
Fruit stains, 296

Gas burners, atmospheric, 282
,, compressed, 19
,, compressors, 283-4
,, irons, 281
,, ,, arrangement of, 281
,, ,, Eaves', 282
,, ,, internal combustion, 280
,, ,, "pressure," 282
,, system, advantages of compressed, 284
Germicidal value of disinfectants, 341
Glanzstoff, 29
Glazes, commercial, 89
,, composition of, 90
Glaze applying machine, 278
,, in finishing, use of, 272, 277
Gloss, production of high, 277
Glossing, 276, 185, 191
,, machines, 203
,, machine, roller, 204
,, ,, ,, 3-roll, 205
,, ,, ,, four-contact roller, 207
,, materials, 88
Glossing materials, mode of action of, 88
Globuline, 88
Glucose, 83, 51
Glycerine, 91
,, in finishing, use of, 272
Goffering, 289
,, machines, 289
Granulose, 77
Grease solvents, 98
,, stains, 298
Grass ,, 299
Gum tragasol, 86-7
,, ,, use of mixtures containing, 275
Gun cotton, 10

Handkerchiefs, cleansing new, 325
,, ,, ironing, 280, 330
,, ,, manufacture of, 321
,, ,, washing process for, 249
,, ,, with coloured effects, treatment of, 327
Hand ironing, 280, 284
,, washing new embroideries, 327
Hardness of water, determination of the, 107
,, ,, permanent, 105, 108, 111
,, ,, temporary, 105, 109, 111
,, ,, total, 108
Heaters, air, 166
Horses for drying rooms, 166
Hot water circulating system, 227
Humidity of air, 264
Hydrogen peroxide, 71, 260, 297, 299
Hydro-extracting, 273, 262
,, extractors, 144-150, 274
,, ,, ball bearings for, 149
Hygrometer, 264
Hygrometric chart, 265
Hygrodeik, 265
Hygroscopic moisture in fibres, 7, 15, 12

Hydrosulphite, A.Z., 299
,, ,, conc., 74
,, ,, N.F. extra, 75
Hyraldite C., extra, 75, 297

Infectious diseases, 339
Indigo carmine, 93
,, extract, 93
,, derivatives, 239
Ink stains, 297
Inks, aniline black, 297
,, nature of marking, 297
,, proprietary ,, 303
,, silver ,, 297
Institution laundry work, I., 333
Ironer and shaper, Shaw, 211
,, five-roll, 179, 181
,, flexible table, 191
,, six-roll, 179
,, three-roll, sectional, 180
Ironers, body, 219, 220
,, edge, 211, 212
,, for boiled starch work, 203, 208
,, multiple-roll, 177, 263
,, neckband, 218
,, steam-heated collar, 209
Ironing, 276-294
,, blouses, 288
,, board, sleeve, 288
,, ,, skirt, 288
,, boiled starch work, 316
,, by hand, 280, 284
,, collar and cuff edge, 276, 278
,, collar, cuff, and front, 276
,, machines, steam, 174
,, miscellaneous articles, 27-290
,, new handkerchiefs, etc., 330

Ironing new work, 310
,, objects of, 176
,, shirt, 285-7
,, skirts, 288
,, underwear, 293
Iron in water, detection of, 109
,, oxalate, 295
,, stains, 297
Irons, electric, 282
,, flat or sad, 280
,, gas, 281
,, internal combustion, 280
,, "pressure" gas, 282-4

Japan wax, 90, 87, 89, 306
Jute, 19
,, chemical composition of, 19

Keratin, 23
Kerosine, 230

Lamp black, 230
Laundering new soft goods, 221
Laundries, hand, 221
Laundry processes, I.
,, work, domestic, 221-2
,, ,, new collar, cuff, etc., 221
,, ,, trade, 300, 2.
,, ,, institution, 333
Lessives, 39
Lintner degree, 53
Lubricating oil, free acid in, 304

Magnesium salts in water, detection of, 106
Malt enzymes, 226, 246
,, ,, liquefying and saccharifying powers of, 246
,, extract, manufacture of, 50
,, ,, uses and valuation of, 53
,, extracts, analyses of, 59
,, manufacture of, 50
,, preparations, 226, 245, 246
Maltose, 51
Mangles, cylinder steam, 181
Mercerised cotton, detection of, 12
Mercerising, 11
Maize starch, 78, 243, 247
Marine acid, 62
Marking, 221, 222
,, coloured thread for, 222
,, inks, 221, 222
,, machines, 303
,, new goods, 303
,, pens, 222
,, systems, 223
,, tags, aluminium, 222
,, tapes, 222

Mercuric chloride, 96
,, ,, as a disinfectant, 340, 342
Microbes, non-pathogenic, 339
,, pathogenic, 339, 342
Mineral oil stains, 298
Mohair, 21
Monopole soap, 40

Neckband and yoke press, 198
,, ironers, 218
,, rings, 219
,, starcher, 158
New work, impurities in, 304
,, ,, ironing, 310
,, ,, soap for, 306

Ochre, red, 230
Oil, cocoa nut, 32, 34, 35
,, cotton seed, 5, 32, 33, 35, 230
,, soluble, 91
Oils for sewing machines, 304
,, used in soap making, 33-5
,, free acid in vegetable, 304
Olein, 33
Oleine, 91, 330
Oleate, sodium, 230
Oven, drying, 162
Oxycellulose, 12

Paint stains, 298
Pearlash, 47
Perborates, 72
Perboric acid, salts of, 72
Permutite, 120
Perspiration stains, 225, 239
Petroleum benzine, 98
Phenol, 96
Pillow covers, ironing, 280
,, shams, ,, 280
,, slips, washing process for, 250
Polishing, 185
Potassium carbonate, 47
,, cyanide, 297
,, hydroxide, 47
,, permanganate, 73, 97
Potato starch, 79, 243
Press, hand bosom, 203
,, neckband and yoke, 198
,, power bosom, 199
,, plant, American, 195-203
Presses, cuff, 196
,, dampening, 288
,, steam collar, 192, 193
,, ,, cuff, 194, 196
,, ,, shirt, 194, 195
Protein content in malt extract, estimation of, 58
Prussian blues, 92-3
Pyroxylin, soluble, 9.

Quillaia bark, 49

Ramie, 19
Raw starch process, 270, 152
,, ,, ,, modified, 274
,, ,, mixture, preparation of, 271
,, ,, suspension, physical properties of, 319
Recipes for soap making, 34-5
Resin in soap making, use of, 32
Retting flax, 13, 14
Rhea, 19
Ribbon feed device, 176
Rinsing, 225, 233, 234
,, in raw starch suspension, 308
Robes, cleansing new, 330
Rongalite C, 75

Sal-ammoniac, 103
Salt cake, 43
Saponification of fats, 31
Saponin, 49
Scalding new embroideries, 326
Scroop, 27
,, inducing, 293
Seam dampeners, 212-3
Shaping machines, collar and cuff, 215-217
,, collars and cuffs, 276, 278
,, double collars, 278
Sheets, cleansing new, 330-1
,, washing process for, 250
Shirt board, 188
,, ,, Sekian's, 190
,, bosoms, ironing, 188-9
,, bosoms and cuffs, starching, 275
,, presses, steam, 194
Shirts, ironing negligé, 190
,, ,, Oxford, 190
Silk, 25
,, action of chemicals on, 27
,, Chardonnet, 29, 10
,, chemical composition of, 27
,, goods, finishing, 293
,, ,, washing, 257
,, structure and properties of, 26
,, substance, 25
,, varieties of, 25
,, viscose, 29
,, wild, 28
Skirt ironing board, 288
Sleeve ,, ,, 288
Smalts, 92, 239
Soap, acid, 231
,, bark, 49
,, basic, 229, 231
,, brown or black, 32
,, composition of, 30
,, detergent action of, 229-231
,, emulsions, 229
,, hydrolysis of, 229
,, manufacture of, 32
Soap, monopole, 40
,, mottled, 31
,, olive oil, 32
,, powders, 39
,, solution, stock, 225
,, solutions, alcoholic, 231
,, ,, physical properties of, 230
,, soot colloidal compound, 230
,, white curd, 31
,, valuation of, 36-8
Soaps, benzine, 40
,, hard, 32
,, insoluble, 107
,, recipes for making, 34-5
,, soft, 32, 33
Soda ash, 42
Sodium bisulphite, 74, 239, 296
,, carbonate, 42-44
,, ,, stock solution of, 224
,, hydrate, 46
,, hydrosulphite, 74
,, hypochlorite, 67, 233, 335, 237, 247, 296, 299, 305
,, ,, bleaching action of, 238
,, oleate, 230
,, perborate, 72, 239, 247, 296, 299, 305
,, peroxide, 71, 260
,, phosphate, 103
,, sesquicarbonate, 42
,, silicate, 47
,, sulphoxylate formaldehyde, 75
,, thiosulphate, 75, 239
,, tungstate, 104
Softening materials, action of, 91
Soft finished goods, classification of, 321
,, ,, ,, embroidered, 321
,, ,, ,, laundering of, 324
,, ,, ,, manufacture of, 320, 321
,, ,, ,, wringing, 330
Soluble glass, 47
,, starch, 84, 51, 55
Solvents, non-inflammable, 99
Solvay soda process, 42
Sorting, 221-2
,, room, 222
Souring and sours, 59, 60
,, new embroideries, 331
Spirits of salt, 62
Squeezing in boiled starch process, 308
Starch, 76
,, arrowroot, 79
,, boiled, 306
,, cassava, 79
,, cellulose, 76
,, cookers, 312

Starch, "double," 306
,, maize, 78, 243, 247
,, potato, 79, 243
,, rice, 79, 243, 247
,, soluble, 84
,, surface, 273, 313
,, tapioca, 79
,, wheaten, 79
,, valuation of, 81
Starches, analyses of various, 82
,, commercial combined, 275
,, thin boiling, 82, 311
Starcher, neckband, 158
,, wristband, 158
Starching, 234, 243, 270-2
,, by hand, 275
,, collars and cuffs, 272
,, common articles, 276
,, machines, 272
,, miscellaneous articles, 275
,, process, modified cold, 274
,, processes, general remarks on, 317-20
,, shirt fronts and cuffs, 275
,, soft finished goods, 329
,, with boiled starch, 311
,, ,, "double starch," 307, 309
,, ,, Hoffmann's machine, 274
Stains, blood, 296
,, dye, 299
,, fruit, 296
,, grease, 298
,, grass, 299
,, ink, 297
,, iron, 297
,, mineral oil, 298
,, modes of removing, 295-9
,, on textiles, occurrence of, 295-9
,, paint, 298
,, perspiration, 225
,, removal of, 295
,, tar, 298
,, tea, 296
,, varnish, 298
Steam bolts, 290
Steaming, 185, 276, 277
,, machines, 186
,, table, 293-4
Stearic acid, sodium salt of, 107
Sterilization, 339
Stockings and socks, 259
Stretcher, ratchet, 190
Suds, first, 229-231
Sulphates in water, detection of, 106
Sulphur dioxide, 76
Surface dampener, 278
,, starch, 313
Swiss embroideries, cleansing, 325

Table "linen," washing process for, 248
Tab tipper, 279
Talc, 94
Tallow in soap making, 32
Tape starchers, 312
Tar stains, 298
Tea ,, 296
Tetrapol, 40
Thin boiling starches, 82, 311
Tipper, tab, 279
Titanous chloride, 76
,, sulphate, 76
Towels, manufacture of, 321
,, rapid drying of, 269
,, washing, 249, 250
Tragasol, gum, 86-7, 275
Tristearin, 30
Turnbull's blue, 93
Turpentine, 100
Treichler's washing system, 140
Tumbler, dry room, 268
,, "Ibis" 262
Turkey red oil, 330
Typhus germs effect of chlorine on, 340

Ultramarine blue, 92, 239
Underwear, ironing, 293
Union cloth, 4
,, ,, in collar manufacture, 301
Unsaponifiable oils on new work, 304

Vapour, aqueous, 263
,, dampeners, 287
Varnish stains, 298
Viscose, 29
Vitriol, oil of, 62

Washer, "Ibis" flannel, 255
,, "Troy" ,, 256
,, "Waterleap" flannel, 256
,, Williamson's ,, 253
Washers, driving and reversing gear of rotary, 133
,, compartment rotary, 136
,, for institutions, 333-4
,, foul, 335-7
,, iron standard for rotary, 134
,, open end, 142
,, "pressure," 133-343
,, rotary, 122-143
,, ring attachment for, 125
Washing, 221
,, cotton and linen goods, 224
,, foul "linen," 335
,, hand embroideries, 326
,, in troughs, 333
,, machine embroideries, 326

Washing new bedspreads, sheets, robes, etc., 330-1
,, new work, 304
,, ,, handkerchiefs, 325
,, powders, 39
,, process for body linen, 249
,, ,, ,, dusters, 249
,, ,, ,, handkerchiefs, 249
,, ,, ,, coloured cotton and linen goods, 251-2
,, ,, for pillow slips, 250
,, ,, ,, silk goods, 257
,, ,, ,, sheets, 250
,, ,, ,, towels, 249
,, ,, French, 226
,, processes, examples of, 242-252
,, ,, for curtains, 250-1
,, ,, ,, new collars, cuffs, etc., 305
,, ,, ,, table "linen," 248
,, ,, ,, wool and silk goods, 252-9
,, soda, 42
,, Swiss embroideries, 325
,, with soap and alkali, 229
Water containing iron, 109
,, dissolved impurities in, 110
,, determination of hardness of, 107
,, for laundering, 105
,, hard, 105
,, purification, 109
,, rain, 105
,, spring, 105
,, suspended impurities in, 110
,, well, 105
,, softening, general remarks on, 118-120
Water softening, permutite system of, 120
,, ,, machine, Lassen and Hjort, 117
,, ,, machine, Simplex, 112
Wax, Japan, 87
Westron, 100
Westrosol, 100
Wing point tipper, "Troy," 278
"Wiping down," 273, 276
,, new work, 312
Wood washing machines, 123
Wool, 20
,, action of heat on, 22
,, ,, ,, chemicals on, 24
,, chemical composition of, 23
,, shrinkage of, 252
,, structure and properties of, 21
,, sulphur in, 23
,, varieties of, 21
Wool and silk goods, coloured, 259
,, ,, ,, bleaching, 259
Woollen goods, fine, 257
,, ,, drying, 267
Woollens, ordinary white, 257
Woollen goods, finishing, 293-4
,, ,, steam presses for, 294
,, ,, washing, 252-9
Wringing, 262, 273, 306
,, machines, 143-4
Wristband starcher, 158
Writing ink stains, 298

Zeolites, 120
Zinc sulphoxylate formaldehyde, basic, 75
,, chloride, 97

REGISTERED TRADE **IBIS** MARK

The Line of Laundry Machinery sold under the above Trade Mark includes the best designs of both English and American construction, is thoroughly up-to-date in every detail, and is of great interest to Laundrymen who desire to economise in labour whilst ensuring the best results.

Full particulars will be furnished on application

ISAAC BRAITHWAITE & SON

ENGINEERS, LIMITED

IBIS WORKS **KENDAL** AND 67 UPPER THAMES ST. **LONDON, E.C.**

No. 22 KENDAL ← TELEPHONES → No. 116 BANK (2 LINES)

IBIS, KENDAL." ← TELEGRAMS → "THEREUPON, LONDON."

A COMPLETE PLANT MAY BE INSPECTED AT ANY TIME IN OUR LONDON SHOWROOMS

Telegraphic Address:
"KENYON, BURY."

Telephones:
173 *Bury* **1225** *P.O. Ealing.*

JAMES KENYON & SON, Ltd.

DERBY STREET MILLS,
BURY, LANCASHIRE.

Manufacturers of all descriptions of

Woollen Cloths for Decouduns

Endless Blankets,

Collar Machine Felts.

Cotton Sheetings a Speciality for all Classes of Ironing Machines.

All Classes of Woollen Cloths for Machinery Purposes in all Widths.

PEARL DUST,

For Washing Linen and Cotton Goods.

Free from all injurious properties. Saves soap and labour; makes Linen and Cotton goods as white as snow.

MARVELITE,

AN EFFECTIVE CLEANSER.
NON-INJURIOUS.
SAVES SOAP AND ENTIRELY DISPENSES WITH AMMONIA.

Makes Blankets and Woollens Soft and Fleecy.
Prevents Felting and Shrinking.

PURE POTASH SOAPS,

For Washing Blankets, Flannels, Woollen Goods.

ALSO

98/99% Powdered Caustic Soda, Caustic Potash, White Potash Soap, and Chloride of Lime.

Manufactured by

THE UNITED ALKALI CO., Ltd.
GREENBANK WORKS,
ST. HELENS, LANCASHIRE.

Advantages of a Pure Starch.

FINE WORK. This is a necessity in all high-class laundries. It can only be produced by exercising the greatest care in the selection of starch.

Adulterated starch ultimately ruins the linen.

HOFFMANN'S Starch is a starch with a name that has set a high standard in starch purity.

Collars, cuffs, and fronts finished like lustrous white enamel; delicate laces and curtains rendered clean, crisp, and sweet.

Linen finished a snowy white.

A refined starch for a refined trade.

RAPID OUTPUT. The adoption of every labour and time-saving device is of little use if time is lost by waiting for starch to be boiled before it can be used.

HOFFMANN'S Pure Rice "Cat" Brand Starch requires no boiling whatever.

It can be mixed straight from the package and used at once.

This is a mere detail, but its importance is widely appreciated.

With a non-boiling starch like HOFFMANN'S "Cat" Brand the work is accelerated.

LESS USED. HOFFMANN'S Starch reduces the starch consumption, since it is the starch which goes the farthest.

The distinctive individuality of HOFFMANN'S Starch is its unique "body" and substance, which reveal its purity and "all starch" properties

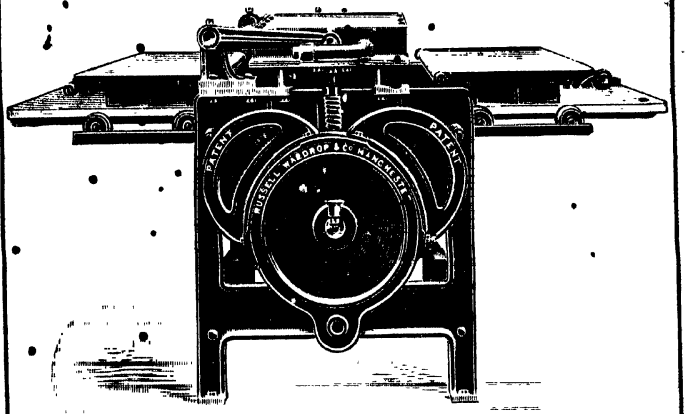
Avoid the starch containing injurious adulterants. The results are disappointing compared with the excessive quantity used.

HOFFMANN'S Starch produces ideal results by the use of a minimum amount, since it is a pure rice product free from adulteration.

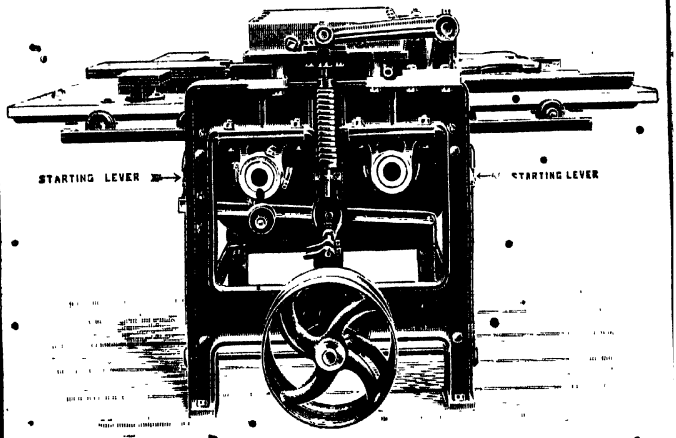
Why not have the best starch obtainable?

Further Particulars from **HOFFMANN'S,** **67, Southwark Bridge Rd., LONDON, S.E.**

Patent "Semi-Press" Shirt & Collar Ironing Machine



"SEMI-PRESS" IRONER WITH COLLAR BOARDS.
STEAM INLET SIDE OF MACHINE.



"SEMI-PRESS" IRONER WITH SHIRT BOARDS.
STEAM EXHAUST AND DRIVING SIDE OF MACHINE.

RUSSELL, WARDROP & CO.

PRITCHARD STREET, C.-ON-M.

Telegrams: "ARMATURE, MANCHESTER."
Telephone: **6031**, Central

MANCHESTER.

TETRAPOL

The Ideal Cleanser.

PRESERVES · LINEN.

A REAL SPECIALITY.

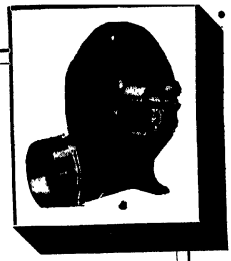
SUPPLIED BY

The BAYER COMPANY, Ltd.

LONDON,	MANCHESTER,	BRADFORD,	GLASGOW,	BELFAST,
19, St. Dunstan's Hill, E.C.	20, Booth Street.	157, Leeds Road.	42, Bothwell Street.	14, Linen Hall Street.

STURTEVANT

DRYING APPARATUS.



Sturtevant Engineering Co. Ltd.

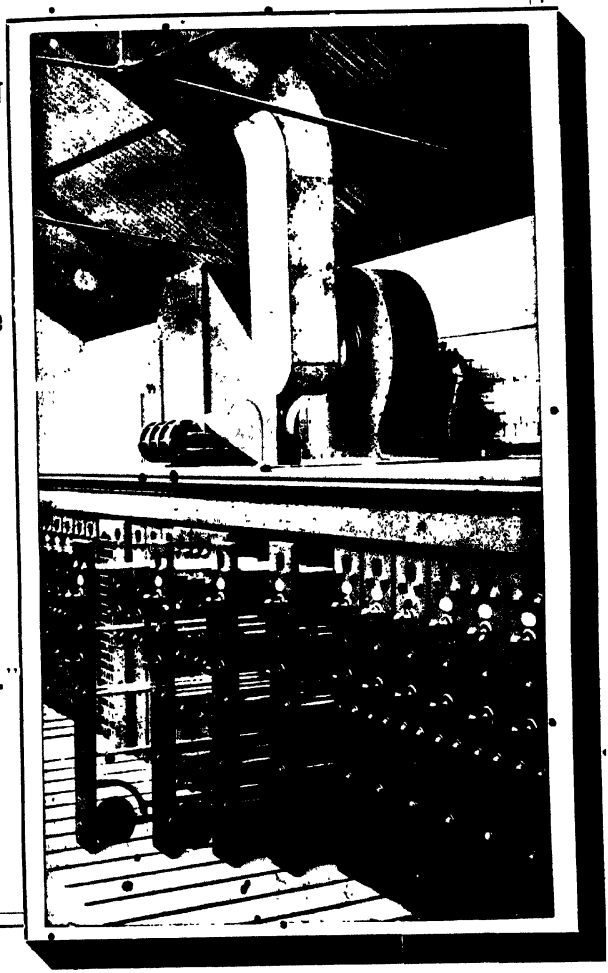
147, Queen Victoria Street, LONDON.

STURTEVANT

FANS

Have the Largest Sale in the World.

Ask for Catalogue "L.W.1081."



DISINFECTORS

Suitable for Laundries.

EFFICIENT, ECONOMICAL, AND MODERATE COST.

Supplied to British and Foreign Governments, Local Authorities, Laundries, &c., &c.

CATALOGUE ON APPLICATION TO

Thresh's Disinfector Co., Ltd.

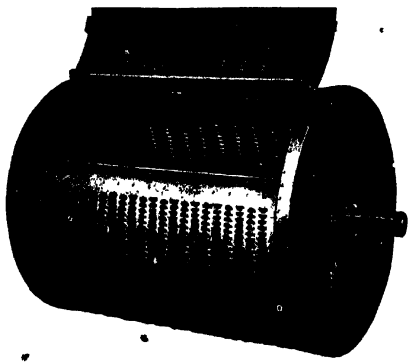
Palace Chambers, Bridge Street,
WESTMINSTER.

JAMES ARMSTRONG & Co., Ltd.

116, QUEEN VICTORIA STREET,

TROY LONDON, E.C.

PATENT TURBINE CYLINDER.



The rows of perforated scoops, opening in reverse directions, produce a cataract-like effect, which ensures quicker washing and a saving in materials.

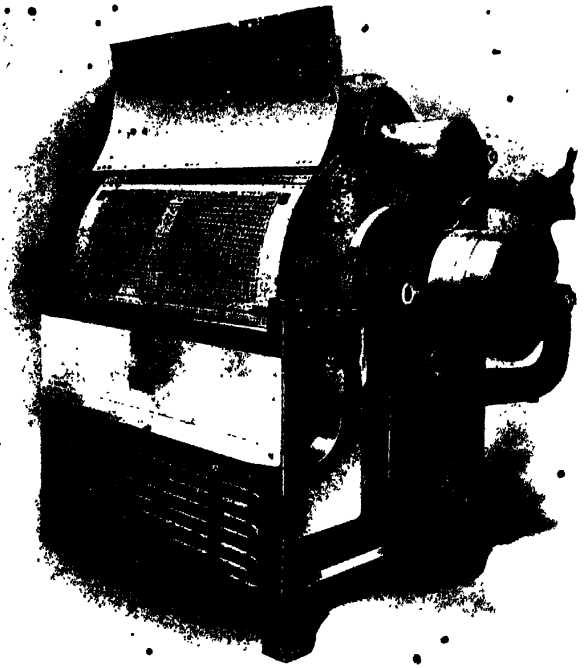
WRITE FOR SPECIAL LEAFLET; also 17th Edition Catalogue.

Telephones { 1476 Central. 1475 City. Telegrams: "TOLAMACO, LONDON."

JAMES ARMSTRONG & CO. LTD.

LAUNDRY ENGINEERS,

116, QUEEN VICTORIA STREET,
LONDON, E.C.



TROY PATENT WOVEN WIRE DRY ROOM TUMBLER.

This Machine will DRY at less expense, in less time, and with less labour than any other method

BATH TOWELS, SHEETS, WOOLLENS, SHIRTS, ROLLER TOWELS, BLANKETS, QUILTS, UNDERWEAR, DYER'S DRYING, ETC., ETC.

Extract from Testimonial, NETHERLEE LAUNDRY, CATHCART, 13/8/1911.

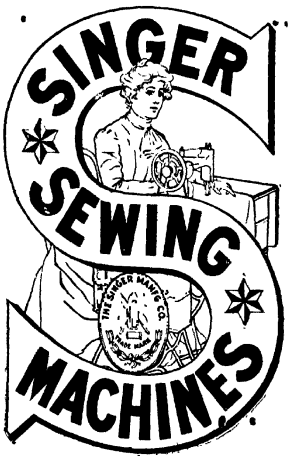
The Drying Tumbler which I bought from you has been working most satisfactorily for the last three weeks. The work turned out leaves nothing to be desired. Flannels, Woollens, and Blankets are done in a way that cannot be approached by any other process that I have seen. It is also very useful for Heavy Bed Mats and Bath Towels, and saves a tremendous amount of time at the Calender. *(Signed)* JOHN B. MATHER.

Write for Special Pamphlet giving full particulars.

SINGER SEWING MACHINES.

Indispensable for work on all classes of Linen and Cotton Goods.

MACHINES
For Button Holes,
Button Sewing,
Collars & Cuffs,
Darning,
Eyelets,
Hosiery,
Hemstitching (Shire, Punch, or Revere),
Ornamental and Zig-zag Stitching,
&c., &c.



LAUNDRY PROPRIETORS and MANAGERS should at once become acquainted with our 16 K 117 MACHINE for Darning Linen, Tablecloths, Sheets, Towels, &c., and the 16 K 119 MACHINE for Darning or Mending Lace Curtains.

Judging from the large number of Testimonials we have received, no Laundry can afford to be without the Singer Darning Machines.

AFTER AN ARTICLE HAS BEEN REPAIRED WITH THEM THE DARN IS SCARCELY DISCERNIBLE.

TEST THIS CLAIM TO-DAY. A Machine will be sent to any Laundry in the United Kingdom for testing FREE OF CHARGE.

Send a Post Card or call at any Singer Shop, or ask any Singer Salesman to send you one for Free Trial.

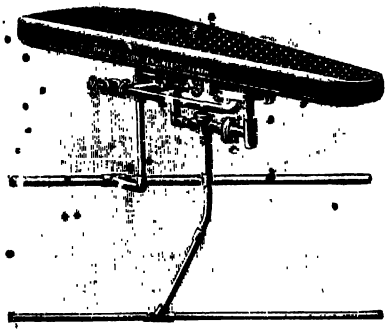
Singer Sewing Machine Co., Ltd.

SHOPS EVERYWHERE.

Benzine, Cleaners, Dyers, and Launderers' Machinery.

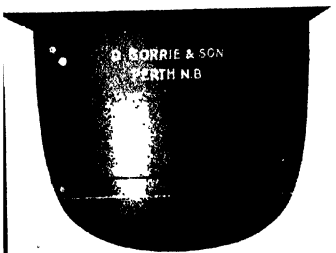
Laundrymen, do your own BENZINE CLEANING.

Complete Installations for power from £100 (including Spotting Agents and instructions).

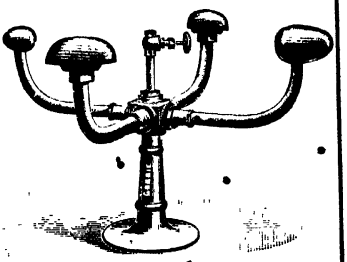


OVER 75,000 Machines and Appliances in use up to the present time, which speaks well of our manufactures.

STEAMING TABLE, for Flannels, Woollens, &c.



COPPER BOILERS, with or without Stands, Boiling Pipe, &c.



STEAM-HEATED FINISHING BOLTS. Over 100 different sizes in stock.

David Gorrie & Son,

ENGINEERS and COPPERSMITHS,

DEPT. B. PERTH, Scotland.

ESTABLISHED 1844.

TRAGASOL

THE FINEST MATERIAL

FOR THE FINEST FINISH.

SUPERFINE RESULTS.

Fabrics strengthened, not tendered. A pure product. Simple. Self-contained.

EVERY LAUNDRY SHOULD USE IT.

The Gum Tragasol Supply Co.

Limited,

HOOTON, BY CHESTER.

White Marseilles Soaps

Amber Soap Flakes

Containing 88% of Real Soap.

Starches—all kinds.

P.D. Strip—for removing Colour Stains from White Goods.

Linen Oil—the Finest Glaze on the Market.

Samples and Prices on application to

PRONK, DAVIS & CO.

13, Haydon St., Minories, LONDON, E..

BRUNNER, MOND & CO., Ltd.

NORTHWICH, CHESHIRE.

CRESCENT BRAND.

GUARANTEED 58 DEGREES.

Equal to 98 Per Cent. Carbonate of Soda.

PURE ALKALI.

The Strongest and Purest form of the Article in the Market, and therefore the most economical for the use of Launderers, Printers, Bleachers, Wool Scourers, Dyers, Glass, Paper, and Soap Makers.

BICARBONATE OF SODA.

Refined and Recrystallized. The Purest and Cheapest in the Market.

BLEACHING POWDER.

35 Per Cent.

CAUSTIC SODA.

Exceptionally Pure.
Strengths: 76/77 Per Cent., 70/72 Per Cent., 60/62 Per Cent.

SODA CRYSTALS of the Finest Quality.

CONCENTRATED CRYSTAL SODA

(SESQUI CARBONATE).

The Purest and Cheapest form of WASHING SODA.
ONE LB. of Concentrated Crystal Soda does the work of TWO LBS. of Washing Soda.
Constant Composition in all Climates. Readily Soluble.
Harmless to the Finest Fabrics and to the Skin.

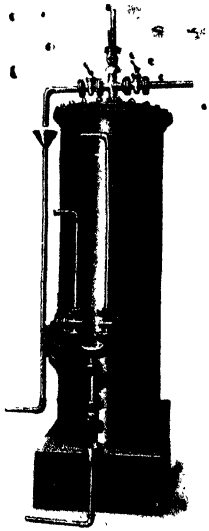
THE

"PERMUTIT" SYSTEM

OF

Water Softening and Purification.

SODIUM PERMUTIT will entirely remove Calcium and Magnesium from hard water, thereby reducing the hardness to 0° and ensuring a maximum saving in soap, alkali, and starch, and at the same time furnish a boiler feed-water which will not cause the formation of any scale or deposit in boilers or heaters.



Manganese PERMUTIT will absolutely eliminate all traces of iron and manganese from water, and thus make an otherwise useless water quite satisfactory for bleaching, dyeing, washing, or any similar operation.

No mechanical parts.

No sludge.

No automatic parts to get out of adjustment.

No settling tanks or filters.

Absolutely automatic for all quantities and qualities.

Treated water always 0° hardness, and always free from suspended matter.

No possibility of incorrect treatment.

WATER SOFTENERS LIMITED,

Telegrams: "AQUADOLCE, LONDON,"
Telephone: 5275 BANK.

91-93, Queen Victoria Street,
LONDON, E.C.

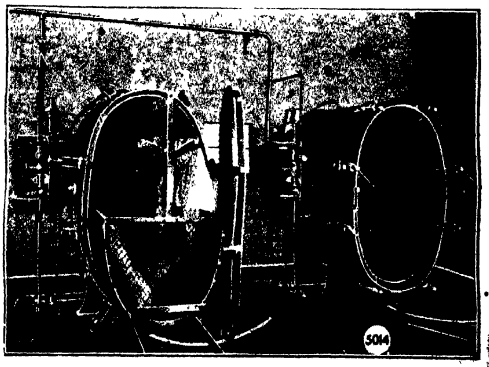
MANLOVE, ALLIOTT & CO., Ltd.

LAUNDRY
ENGINEERS,
Nottingham.

FOR
High-class
Laundry ::
Machinery.

ALSO
Steam :: ::
Disinfectors,
Sterilizers, ::
&c., &c.

WRITE FOR LISTS:
Laundry Machinery—K 211.
Disinfectors and Sterilizers—K 212.



Brax Diastase Extract "B.D.E."

A Pure and Highly Diastasic Malt Extract, specially suitable for use in

LAUNDRIES.

The following are among the advantages derived from the use of "B.D.E." in the wash-house:—

Reduction in washing materials, "B.D.E." removing much of the dirt in the process of dissolving the starch.

Saving in labour and materials through less re-washes.

Colour and quality of work vastly improved.

Greater satisfaction to customers owing to LESS WEAR AND TEAR of linen.

A special pamphlet is also issued on the advantages resulting from the use of "B.D.E." in the STARCH ROOM.

"B.D.E." IS SUPPLIED EXCLUSIVELY BY

BRAX, LIMITED,

Needham Market, Suffolk.

(CONTRACTORS TO H.M. GOVERNMENT).

Sole Agents for England and Ireland:—

PRONK, DAVIS & CO., 13, Haydon St., Minories, LONDON, E.; and at 24, Pershore Street, BIRMINGHAM.

Sole Agents for Scotland:—

DAVID CRAWFORD & CO., 59, Bath Street, GLASGOW.

"THE MACHINE THAT HAS REVOLUTIONISED WATER SOFTENING."

THE

LASSEN & HJORT

Water Softener & Purifier

(HOT OR COLD PROCESS).

Prominent Users of

THE LASSEN & HJORT SOFTENER:

Messrs. Babcock & Wilcox, Ltd.
,, Marshalls, Sons & Co., Ltd.
,, Ruston, Procter & Co., Ltd.
,, Crompton & Co., Ltd.
Messrs. J. & P. Coats, Ltd.
,, Peek, Frean & Co., Ltd.
,, Galloways, Ltd.
,, General Electric Co., Ltd.
The British Admiralty and War Office.
Armstrong, Whitworth & Co., Ltd.
The Metropolitan Water Board.

Enquiries to

LASSEN & HJORT, 52, Queen Victoria St., E.C.

IN PROGRESS.

BY THE SAME AUTHOR.

A MANUAL OF COTTON & LINEN BLEACHING.

A volume dealing with Modern Practice in Bleaching all kinds of Cotton and Linen Goods, and with the Chemical and Mechanical Principles involved.

BELFAST:
E. CLAYTON,
Deerpark Road.

MARSDEN & Co., Ltd.

Engravers, Printers, and Manufacturing Stationers.

DEPARTMENTS.

Printing.	Drawing.
Bookbinding.	Engraving.
Account Books.	Process Etching.
Publishing.	Electrotyping.

ENGINEERS' CATALOGUES :: :: A SPECIALITY. :: ::

Carr Street, Blackfriars Street,
MANCHESTER.

PRINTERS OF THIS WORK.

BY APPOINTMENT

Purveyors of Starch to H.M. the King.

BY APPOINTMENT

Manufacturers of Starch and Blue to H.M. Queen Alexandra.

Modern Launderers

Desiring to Produce
Up-to-Date Results for
Themselves and Customers

WILL FIND

COLMAN'S

Laundry Starches and Blues

INVALUABLE.

J. & J. COLMAN, LIMITED,

LONDON and NORWICH.

ENTIRELY BRITISH MAKE

We shall be pleased to submit Prices for

Single Machines,

or to

prepare ESTIMATES and PLANS for COMPLETE INSTALLATIONS.

ENQUIRIES INVITED.

LAUNDRY MACHINERY

(Hand or Power) for Public or Institution Laundries.

CONTRACTORS TO The ADMIRALTY, WAR OFFICE, HOME OFFICE, &c.

THE CHERRY TREE MACHINE CO., Ltd.

MAKERS of High-class Laundry Machinery,

BLACKBURN, Lancs.

TELEPHONE: 22, Pleasington.
TELEGRAMS: "FOUNDRY, CHERRY TREE."

Greater Economy

may be effected by the use of the

PAYNE & STAYNES'

WATER PURIFICATION

Process, Patented in England, United States of America, and other countries.

ALL Calcium, Magnesium, Iron, & Aluminium Impurities

Removed

irrespective of their amounts or states in which they may exist. The practical results obtained by the use of water purified by the process warrant the claim that for certain businesses and manufactures it is

Unrivalled

FOR TERMS OF LICENSE AND OTHER PARTICULARS APPLY TO—

W. H. STAYNES,

The Ferns, Belgrave, LEICESTER.

Pure . . Soft . . Water

THE FIRST ESSENTIAL FOR EVERY

LAUNDRY

SUITABLE FOR THE
LARGEST LAUNDRIES.

ADVANTAGES:

GREAT SAVING IN SOAP.
IMPROVED WORK, thus bringing increased business.

SUITABLE FOR THE
SMALLEST
LAUNDRIES.

WILLIAM

BOBY'S

Water Softeners

Send for "Laundry Catalogue."

Salisbury House,
London Wall,
LONDON, E.C.

APPENDIX.

USEFUL TABLES.

Comparison of Temperature Degrees.

Centigrade or Celsius.	Fahrenheit.	Centigrade or Celsius.	Fahrenheit.
−10	+14·0	46	114·8
− 9	15·8	47	116·6
− 8	17·6	48	118·4
− 7	19·4	49	120·2
− 6	21·2	50	122·0
− 5	23·0	51	123·8
− 4	24·8	52	125·6
− 3	26·6	53	127·4
− 2	28·4	54	129·2
− 1	30·2	55	131·0
0	32·0	56	132·8
+ 1	33·8	57	134·6
2	35·6	58	136·4
3	37·4	59	138·2
4	39·2	60	140·0
5	41·0	61	141·8
6	42·8	62	143·6
7	44·6	63	145·4
8	46·4	64	147·2
9	48·2	65	149·0
10	50·0	66	150·8
11	51·8	67	152·6
12	53·6	68	154·4
13	55·4	69	156·2
14	57·2	70	158·0
15	59·0	71	159·8
16	60·8	72	161·6
17	62·6	73	163·4
18	64·4	74	165·2
19	66·2	75	167·0
20	68·0	76	168·8
21	69·8	77	170·6
22	71·6	78	172·4
23	73·4	79	174·2
24	75·2	80	176·0
25	77·0	81	177·8
26	78·8	82	179·6
27	80·6	83	181·4
28	82·4	84	183·2
29	84·2	85	185·0
30	86·0	86	186·8
31	87·8	87	188·6
32	89·6	88	190·4
33	91·4	89	192·2
34	93·2	90	194·0
35	95·0	91	195·8
36	96·8	92	197·6
37	98·6	93	199·4
38	100·5	94	201·2
39	102·2	95	203·0
40	104·0	96	204·8
41	105·8	97	206·6
42	107·6	98	208·6
43	109·4	99	210·2
44	111·2	100	212·0
45	113·0		

WEIGHTS AND MEASURES.

I.—Metric System.

1 metre (m.) = 10 decimetres (dm.) = 100 centimetres (cm.) = 1,000 millimetres (mm.).

1 litre (l.) = 1,000 cubic centimetres (c.c.). 1,000 litres = 1 cubic metre (cb.m.).

1 gramme (grm.) = 10 decigrammes (dg.) = 100 centigrammes (cg.) = 1,000 milligrammes (mg.).

1 kilogramme (kg. or kilo.) = 1,000 grammes. 1,000 kilogrammes = 1 metric ton.

100 kilogrammes = 1 quintal. 50 kilogrammes = 1 centner.

10 grammes = 1 dekagramme (dg.). 100 grammes = 1 hektogramme (hg.).

In the metric system, the unit of weight is the gramme, which is the weight of 1 cubic centimetre of water at its greatest density. We thus have the following relationship between weights and measures:—

1 cubic centimetre of water = 1 gramme.

1 litre ,, ,, = 1 kilogramme.

II.—Conversion of Metric into English Measures.

1 cubic centimetre	=	17 minims.			
2 cubic centimetres	=	34	,,		
3 ,, ,,	=	51	,,		
4 ,, ,,	=	68	,,	= 1 drachm	8 minims.
5 ,, ,,	=	85	,,	= 1 ,,	25 ,,
6 ,, ,,	=	102	,,	= 1 ,,	42 ,,
7 ,, ,,	=	119	,,	= 1 ,,	59 ,,
8 ,, ,,	=	136	,,	= 2 drachms	16 ,,
9 ,, ,,	=	153	,,	= 2 ,,	33 ,,
10 ,, ,,	=	170	,,	= 2 ,,	50 ,,
20 ,, ,,	=	340	,,	= 5 ,,	40 ,,
30 ,, ,,	=	510	,,	= 1 ounce	0 drachm 30 minims.
40 ,, ,,	=	680	,,	= 1 ,,	3 drachms 20 ,,
50 ,, ,,	=	850	,,	= 1 ,,	6 ,, 10 ,,
60 ,, ,,	=	1,020	,,	= 2 ounces	1 drachm 0 ,,
70 ,, ,,	=	1,190	,,	= 2 ,,	3 drachms 50 ,,
80 ,, ,,	=	1,360	,,	= 2 ,,	6 ,, 40 ,,
90 ,, ,,	=	1,530	,,	= 3 ,,	1 drachm 30 ,,
100 ,, ,,	=	1,700	,,	= 3 ,,	4 drachms 20 ,,
1,000 ,, ,,	=	1 litre	,,	= almost 34 fluid ounces, or 1¾ pints.	

Table showing Comparison between Hydrometer Degrees.

(Twaddell and Baumé).

Twaddell	Baumé	Twaddell	Baumé	Twaddell	Baumé	Twaddell	Baumé
0	0	26	16·5	51	29·3	76	39·8
1	0·7	27	17·1	52	29·7	77	40·1
2	1·4	28	17·7	53	30·2	78	40·5
3	2·1	29	18·3	54	30·6	79	40·8
4	2·7	30	18·8	55	31·1	80	41·2
5	3·4	31	19·3	56	31·5	81	41·6
6	4·1	32	19·8	57	32·0	82	42·0
7	4·7	33	20·3	58	32·4	83	42·3
8	5·4	34	20·9	59	32·8	84	42·7
9	6·0	35	21·4	60	33·3	85	43·1
10	6·7	36	22·0	61	33·7	86	43·4
11	7·4	37	22·5	62	34·2	87	43·8
12	8·0	38	23·0	63	34·6	88	44·1
13	8·7	39	23·5	64	35·0	89	44·4
14	9.4	40	24·0	65	35·4	90	44·8
15	10·0	41	24·5	66	35·8	91	45·1
16	10·6	42	25·0	67	36·2	92	45·4
17	11·2	43	25·5	68	36·6	93	45·8
18	11·9	44	26·0	69	37·0	94	46·1
19	12·4	45	26·4	70	37·4	95	46·4
20	13·0	46	26·9	81	37·8	96	46·8
21	13·6	47	27·4	72	38·2	97	47·1
22	14·2	48	27·9	73	38·6	98	47·4
23	14·9	49	28·4	74	39·0	99	47·8
24	15·4	50	28·8	75	39·4	100	48·1
25	16·0						

Percentages of Water in Glycerine of known Specific Gravity at 15° C.

Specific Gravity	Degrees Tw.	Per cent. of Water	Specific Gravity	Degrees Tw.	Per cent. of Water
1·2610	52·8	0·0	1·2320	46·4	12·0
1·2585	51·7	2·0	1·2270	45·4	14·0
1·2530	50·6	4·0	1·2215	44·3	16·0
1·2480	49·6	6·0	1·2165	43·3	18·0
1·2425	48·5	8·0	1·2110	42·2	20·0
1·2375	47·5	10·0	1·2085	41·7	21·0

Percentages of Acetic Acid in Liquors of known Specific Gravity at 15° C.

(Oudemans).

Specific Gravity	Per cent. $C_2H_4O_2$	Specific Gravity	Per cent. $C_2H_4O_2$	Specific Gravity	Per cent. $C_2H_4O_2$	Specific Gravity	Per cent. $C_2H_4O_2$
0'9992	0	1'0340	25	1'0615	50	1'0746	75
0'0007	1	1'0363	26	1'0623	51	1'0747	76
0'0022	2	1'0375	27	1'0631	52	1'0748	77
0'0037	3	1'0388	28	1'0638	53	1'0748	78
0'0052	4	1'0400	29	1'0645	54	1'0748	79
0'0067	5	1'0412	30	1'0653	55	1'0748	80
0'0083	6	1'0424	31	1'0660	56	1'0747	81
0'0098	7	1'0436	32	1'0666	57	1'0746	82
0'0113	8	1'0447	33	1'0673	58	1'0744	83
0'0127	9	1'0459	34	1'0679	59	1'0742	84
0'0142	10	1'0470	35	1'0685	60	1'0739	85
0'0157	11	1'0481	36	1'0691	61	1'0736	86
0'0171	12	1'0492	37	1'0697	62	1'0731	87
0'0185	13	1'0502	38	1'0702	63	1'0726	88
0'0200	14	1'0513	39	1'0707	64	1'0720	89
0'0214	15	1'0523	40	1'0712	65	1'0713	90
0'0228	16	1'0533	41	1'0717	66	1'0705	91
0'0242	17	1'0543	42	1'0721	67	1'0696	92
0'0256	18	1'0552	43	1'0725	68	1'0686	93
0'0270	19	1'0562	44	1'0729	69	1'0674	94
0'0284	20	1'0571	45	1'0733	70	1'0660	95
0'0298	21	1'0580	46	1'0737	71	1'0644	96
0'0311	22	1'0589	47	1'0740	72	1'0625	97
0'0324	23	1'0598	48	1'0742	73	1'0604	98
0'0337	24	1'0607	49	1'0744	74	1'0580	99
						1'0553	100

NOTE.—The specific gravities above 1'0553, *i.e.*, 11° Tw., correspond to two liquids of different strength. To find if a certain volume contains more or less than 77° $C_2H_4O_2$, a little water is added; if the specific gravity increases, the acid contains more than 77 %, while if it decreases a lower percentage is indicated.

Percentages of Formic Acid in Liquors of known Specific Gravity at 70° F. (compared with water at 40° F.).

(Richardson and Allaire).

Specific Gravity	% of CH_2O_2 by Weight	% of CH_2O_2 by Volume	Specific Gravity	% of CH_2O_2 by Weight	% of CH_2O_2 by Volume	Specific Gravity	% of CH_2O_2 by Weight	% of CH_2O_2 by Volume
0'9983	0	0'00	1'0247	10	8'40	1'1425	60	56'13
1'0020	1	0'82	1'0371	15	12'80	1'1544	65	61'44
1'0045	2	1'64	1'0489	20	17'17	1'1656	70	66'80
1'0071	3	2'48	1'0610	25	21'73	1'1770	75	72'27
1'0094	4	3'30	1'0730	30	26'37	1'1861	80	77'67
1'0116	5	4'14	1'0848	35	31'10	1'1954	85	83'19
1'0142	6	4'98	1'0964	40	35'90	1'2045	90	88'74
1'0171	7	5'81	1'1086	45	40'82	1'2141	95	94'48
1'0197	8	6'68	1'1208	50	45'88	1'2213	100	100'00
1'0222	9	7'55	1'1321	55	51'01			

Percentages of Ammonia in Ammonia Liquors of known Specific Gravity, at 15° C.

(Lunge and Wiernik).

Specific Gravity at 15°	Per Cent. NH_3	Correction of the Specific Gravity for ± 1° C.	Specific Gravity at 15°	Per Cent. NH_3	Correction of the Specific Gravity for ± 1° C.	Specific Gravity at 15°	Per Cent. NH_3	Correction of the Specific Gravity for ± 1° C.
1·000	0·00	·00018	0·960	9·91	·00029	0·920	21·75	·00047
0·998	0·45	·00018	0·958	10·47	·00030	0·918	22·39	·00048
0·996	0·91	·00019	0·956	11·03	·00031	0·916	23·03	·00049
0·994	1·37	·00019	0·954	11·60	·00032	0·914	23·68	·00050
0·992	1·84	·00020	0·952	12·17	·00033	0·912	24·33	·00051
0·990	2·31	·00020	0·950	12·74	·00034	0·910	24·99	·00052
0·988	2·80	·00021	0·948	13·31	·00035	0·908	25·65	00053
0·986	3·30	·00021	0·946	13·88	·00036	0·906	26·31	00054
0·984	3·80	·00022	0·944	14·46	·00037	0·904	26·98	·00055
0·982	4·30	·00022	0·942	15·04	·00038	0·902	27·65	·00056
0·980	4·80	·00023	0·940	15·63	·00039	0·900	28·33	·00057
0·978	5·30	·00023	0·938	16·22	·00040	0·898	29·01	·00058
0·976	5·80	·00024	0·936	16·82	·00041	0·896	29·69	·00059
0·974	6·30	·00024	0·934	17·42	·00041	0·894	30·37	·00060
0·972	6·80	·00025	0·932	18·03	·00042	0·892	31·05	·00060
0·970	7·31	·00025	0·930	18·64	·00042	0·890	31·75	·00061
0·968	7·82	·00026	0·928	19·25	·00043	0·888	32·50	·00062
0·966	8·33	·00026	0·926	19·87	·00044	0·886	33·25	·00063
0·964	8·84	·00027	0·924	20·49	·00045	0·884	34·10	·00064
0·962	9·35	·00028	0·922	24·12	·00046	0·882	34·95	·00065

The figures given in the third column are corrections to be applied when the specific gravity is determined at a temperature one or two degrees below or above 15°. Thus, if the specific gravity was found to be 0·910 at 17° C., the actual density is obtained by adding $2 \times 0{\cdot}00052 = 0{\cdot}00104$. Hence the correct value is $0{\cdot}910 + 0{\cdot}001 = 0{\cdot}911$, *i.e.*, about 24·66% NH_3.

Percentages of Sulphuric Acid in Liquors of known Specific Gravity at 15° C. *(Lunge and Isler).*

Degrees Twaddell	Per cent. Sulphuric Acid	Degrees Twaddell	Per cent. Sulphuric Acid	Degrees Twaddell	Per cent. Sulphuric Acid	Degrees Twaddell	Per cent. Sulphuric Acid
2	1·57	48	32·28	94	56·90	140	77·17
4	3·03	50	33·43	96	57·83	142	78·04
6	4·49	52	34·57	98	58·74	144	78·92
8	5·96	54	35·71	100	59·70	146	79·80
10	7·37	56	36·87	102	60·65	148	80·68
12	8·77	58	38·03	104	61·59	150	81·56
14	10·19	60	39·19	106	62·53	152	86·44
16	10·90	62	40·35	108	63·43	154	83·32
18	12·99	64	41·50	110	64·26	156	84·50
20	14·35	66	42·66	112	65·08	158	85·70
22	15·71	68	43·74	114	65·90	160	86·90
24	17·01	70	44·82	116	66·71	162	88·30
26	18·31	72	45·88	118	67·59	164	90·05
28	19·61	74	46·94	120	68·51	165	91·00
30	20·91	76	48·00	122	69·43	166	92·10
32	22·19	78	49·06	124	70·32	167	93·43
34	23·47	80	50·11	126	71·16	168	95·60
36	24·76	82	51·15	128	71·99	168·3*	97·70
38	26·04	84	52·15	130	72·82	168·1*	98·70
40	27·32	86	53·11	132	73·64	168*	99·20
42	28·58	88	54·07	134	74·51	167·7*	99·95
44	29·84	90	55·03	136	75·42		
46	31·11	92*	55·97	138	76·30		

* Sulphuric acid of 97·70% has the highest specific gravity, whilst that of stronger acid is a little lower.

Percentages of Hydrochloric Acid in Liquors of known Specific Gravity at 15° C. *(Lunge and Marchlewski).*

Degrees Twaddell	Per cent. Hydrochloric Acid	Degrees Twaddell	Per cent. Hydrochloric Acid	Degrees Twaddell	Per cent. Hydrochloric Acid	Degrees Twaddell	Per cent. Hydrochloric Acid
1	1·15	11	11·18	21	20·97	31	30·55
2	2·14	12	12·19	22	21·92	32	31·52
3	3·12	13	13·19	23	22·86	33	32·49
4	4·13	14	14·17	24	23·82	34	33·46
5	5·15	15	15·16	25	24·78	35	34·42
6	6·15	16	16·15	26	25·75	36	35·39
7	7·15	17	17·13	27	26·70	37	36·31
8	8·16	18	18·11	28	27·66	38	37·23
9	9·16	19	19·06	29	28·61	39	38·16
10	10·17	20	20·01	30	29·57	40	39·11

NOTE.—Each degree Twaddell corresponds approximately to 1% pure hydrochloric acid.

PART I.

THE TEXTILE FIBRES, AND THE MATERIALS, WATER, AND MACHINERY USED IN LAUNDRY WORK.

CHAPTER I.

The Technology of the Textile Fibres.

In order to obtain a right understanding of the principles which govern the chief operations carried on in the laundry, it is essential that the student should make himself acquainted with the physical properties of the textile fibres and their behaviour toward various chemical reagents.

Commercial textile fibres are usually classified as vegetable and animal fibres, according to the sources from which they are obtained. In addition to these, there is a third class, which includes all fibres made by artificial means. To the first-named class belong cotton, flax, jute, hemp, China grass, etc.; wool and silk are the chief representatives of the second class, while the various artificial silks belong to the third class.

Of the fibres derived from vegetable sources, cotton is by far the most important; indeed, it has been said that almost every inhabitant of the earth makes use of textile articles of one kind or another, made either wholly or partly of cotton. Flax is next in importance. It is stronger than cotton, and cloth woven from it yields a better finish. Consequently, it finds extensive employment in the manufacture of high-class household articles, as well as various articles of dress which have to withstand a considerable amount of wear and tear.

The cloth from which the bulk of the articles treated in the laundry is made, is either composed entirely of cotton or of linen, although union cloth, *i.e.*, cloth usually made with a linen weft and cotton warp, is also employed in considerable quantities. Textile articles made from jute, hemp, or China grass, have seldom to be treated in the laundry. It is highly probable, however, that the sphere of usefulness of China grass, especially in connection with the manufacture of household textile articles, will be considerably extended in the near future.

The animal fibres include many varieties of wool, hair, and silk, while the chief raw material used in the manufacture of artificial silks is cellulose, usually in the form of wood pulp.

The members of one class of fibres can be readily distinguished from those of another by means of their different behaviour toward various chemical reagents. For example:—Wool and silk are disintegrated to a greater or less extent on boiling in solutions of caustic soda, and even solutions of sodium carbonate exert a destructive influence under suitable conditions; fibres of vegetable origin, however, are not appreciably affected by these reagents. Again, weak mineral acids slowly disintegrate the members of the latter class, while animal fibres exhibit great resistance toward such liquids. Hot dilute nitric acid colours the animal fibres yellow, and if of sufficient strength causes complete disintegration. The chief varieties of artificial silk belong to the same class of compounds as cotton and linen; hence they are affected by chemical reagents in much the same way. They differ from the cellular fibres, however, in that when wet their tensile strength is comparatively low, and the greatest care is necessary during treatment with water or other cleansing liquids, especially when the latter are used at an elevated temperature. This defect appears to have been more or less completely overcome during the last few years, as some of the varieties of recent introduction exhibit tensile strength in a high degree, even when treated with hot liquids.

SECTION I.—VEGETABLE FIBRES.

COTTON.

The term *cotton* is applied to the white hairy material obtained from various tropical and sub-tropical plants belonging to the genus, *Gossypium*, of the natural order, *Malvaceæ*. The fruit of the cotton plant consists of a pod or capsule, which is divided internally into three or more divisions by means of exceedingly thin walls. Each division contains a number of seeds to which the hairs of cotton are attached. During the gradual development of the hairs or fibres, more and more space is required, until finally they fill the capsules, and their further growth causes the latter to burst. A comparatively short exposure to sun and air completes the development of the fibres, which are subsequently gathered by hand, and the seeds and other foreign matter separated by a mechanical operation known as ginning. On subjecting the seeds to considerable pressure under suitable conditions, cotton seed oil is obtained, while the residue is used as a food for cattle. The ginned cotton is packed into coarse jute bags, compressed by means of steam or hydraulic pressure, and sent to the cotton spinning districts under the general name of raw cotton.

Several species of the cotton plant are known to botanists, but those most generally cultivated are enumerated below:—

1. *Gossypium Barbadense.*—From this species the best quality of cotton—known as Sea Island cotton—is obtained. It is chiefly grown in the southern portion of the United States and in the West Indies. Sea Island cotton is much valued on account of its lustre, strength, and length of staple. The species from which the bulk of the United States cotton crop is obtained is said to be a variety of G. Barbadense. It is known as G. hirsutum, and differs from the latter in that its flowers are white while G. Barbadense yields yellow flowers.

2. *Gossypium Peruvianum.*—This species is chiefly cultivated in the tropical and sub-tropical districts of South America. The plant attains a height of from 10 to 13 feet, and bears yellow flowers. It yields the long-stapled Brazilian and Peruvian cotton.

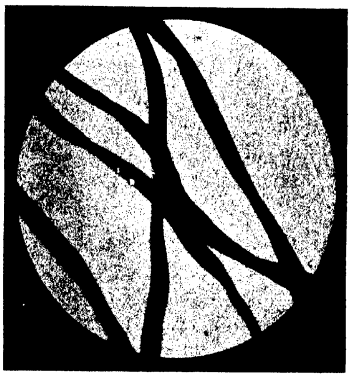


FIG. 1.—COTTON. (× 120 diam.).

3. *Gossypium herbaceum* is of Asiatic origin. It is grown in India, China, Egypt, and America, and yields the Madras, Surat, and short-stapled Egyptian cotton. The plant is bushy and attains a height of from 3 to 4 feet.

4. *Gossypium Arboreum.*—This is usually found in India, China, and certain parts of the United States. It frequently attains a height of from 20 to 25 feet, and bears reddish-purple flowers; it yields a good quality of cotton.

Physical Structure and Properties.—When a ripe cotton fibre is examined under the microscope, it presents the appearance of a band like tube, spirally twisted to a greater or less extent about its axis (Fig. 1). It is pointed and closed at one end, while the

other end, which was originally attached to the seed, presents an irregularly torn appearance. A single cotton fibre consists essentially of a long and comparatively narrow plant cell, with a well defined central canal, which during growth serves for the circulation of the cell sap. The spiral character of the fibre is said to be due to the irregular drying of the cell walls on exposure to sun and air, and this also causes the edges to exhibit a thick rounded appearance. Fibres are frequently met with which on examination are found to be devoid of twist and exhibit a flat appearance. They act differently to ordinary cotton, inasmuch as they resist certain dyes, thus giving rise to white specks on various classes of dyed goods.

Cotton fibres vary considerably in length (from 0.8 to 1.8 inches), and also in width (from 0.0005 to 0.001 inch). As a rule, the shortest fibres have the largest diameter, a statement which is also applicable to other fibres possessing a cellular structure.

The following figures given by Leigh ("*Science of Modern Cotton Spinning*") show the wide variation in length and diameter of the chief commercial varieties of cotton :—

Description of Cotton.	Length of Staple, in Inches.			Diameter of Fibre, in Inches.		
	Min.	Max.	Mean	Min.	Max.	Mean
New Orleans	0·88	1·16	1·02	0·000580	0·000970	0·000775
Sea Island (Long Staple)	1·41	1·80	1·61	0·000460	0·000820	0·000640
Brazilian	1·03	1·31	1·17	0·000620	0·000960	0·000790
Egyptian	1·30	1·52	1·41	0·000590	0·000720	0·000655
Indian (Native Seed)	0·77	1·02	0·89	0·000649	0·001040	0·000844

Under ordinary conditions cotton contains on an average about 8.5 per cent. of hygroscopic moisture, *i.e.*, moisture that can be removed by drying the fibre at an elevated temperature, but which is reabsorbed on cooling in contact with air. It has been shown that the presence of moisture in cotton and other fibres exerts a considerable influence on their physical properties, especially as regards "feel" and elasticity, which in the case of the cotton fibre, and in conjunction with its spiral character, are of the utmost importance in the spinning of fine yarns.

Impurities in Raw Cotton.—About 5 per cent. of impurities is removed from raw cotton during the bleaching process. These consist chiefly of so-called pectic substances, cotton wax, and colouring matter. The difficulty of "wetting out" raw cotton cloth is explained by assuming that each fibre is coated with a minute quantity of wax, which, owing to its water-repellent nature, prevents the ready penetration of the fibres by that liquid.

Chemical Composition and Properties.—Purified cotton fibre consists of a substance known as cellulose, which is very widely distributed in the vegetable kingdom. When subjected to analysis it is found to consist of three elements, viz. :—Carbon, hydrogen, and oxygen, in the following proportions :—

Carbon, 44.2 per cent.
Hydrogen, 6.3 per cent.
Oxygen, 49.5 per cent.

From these figures the simplest formula for cellulose may be deduced, viz. :—$C_6H_{10}O_5$.

Cellulose is slightly heavier than water, in which it is insoluble; it is also insoluble in alcohol, ether, etc., and is characterised by its weak power of undergoing chemical change. Under suitable conditions, however, cellulose can be converted into a large number of interesting and commercially valuable compounds. When heated to a temperature of about 100 deg. C., it loses its hygroscopic moisture, but regains it again on cooling. Long-continued heating at the above temperature, however, causes the fibre to undergo slow disintegration.

At temperatures above 130 deg. C. cellulose chars and is more or less rapidly disintegrated.

Although it is insoluble in the ordinary solvents, it readily dissolves in ammoniacal copper hydrate (Schweitzer's reagent), which may be prepared by precipitating a solution of copper sulphate with caustic soda solution, filtering, washing the precipitate thoroughly, and finally dissolving it in a small quantity of strong ammonia.

A solution of cellulose in ammoniacal copper hydrate is used by several firms in the manufacture of one of the best varieties of artificial silk.

Cellulose is also soluble in a mixture of one part anhydrous zinc chloride and two parts concentrated hydrochloric acid.

Action of Acids.—Mineral acids, such as sulphuric and hydrochloric, have a powerful action on cellulose, the ultimate effect being dependent upon the strength of the acid, its duration of action, and temperature, as well as upon the physical condition of the cellulose. As a rule, hydrochloric acid does not act so energetically as sulphuric acid. Nitric acid acts on cellulose in a somewhat different manner to other mineral acids. Stable cellulose nitrates are formed under certain conditions, while in other cases the cellulose is converted into oxidation products.

Action of Sulphuric Acid.—Cold weak sulphuric acid does not appear to have any action on cellulose under ordinary working conditions. If vegetable fibres are impregnated with the weak acid, however, and subsequently dried without washing, either by

exposure to air or in some other way, they become tendered to a greater or less extent. This result is explained by assuming that the acid becomes concentrated owing to the evaporation of water. If the weak acid is used hot, it readily exerts a disintegrating action, which varies with the temperature and the degree of concentration. Cold strong sulphuric acid completely dissolves cellulose in a comparatively short time, the solution containing substances which are closely allied in composition to the dextrins. If the solution is diluted with water and boiled, glucose is obtained.

When the action of the acid is only allowed to continue for a few seconds, the treated cellulose becomes gelatinous, and, if immediately washed and squeezed, it becomes more tenacious. Upon this fact is based the manufacture of parchment paper. Suitable unsized paper is run through tanks containing sulphuric acid at about 156 deg. Tw., and then thoroughly washed by passing it through other tanks containing water. Finally, the paper is squeezed by heavy squeezing rollers, and subsequently dried. It will be evident that the action of the acid is more or less superficial, so that the final squeezing operation forces the gelatinous surface fibres into intimate contact with the unaltered fibres, and the finished material offers greater resistance towards friction than the untreated paper.

Action of Hydrochloric Acid.—Weak cold hydrochloric acid exerts very little action on cotton cellulose, but it readily attacks the fibre if used hot. Prolonged treatment of cotton fibres with the strong acid causes them to undergo gradual disintegration, while the same effect is produced if the fibres are impregnated with weak acid and subsequently dried by exposure to air or by artificial means. The colourless disintegrated fibre readily falls to powder, and is termed *hydro-cellulose*. The same compound is produced by the action of weak sulphuric acid under similar conditions.

Action of Nitric Acid.—The products formed by the action of cold strong nitric acid on cellulose are very variable in composition and properties. They may be classified as low, intermediate, and high nitrated products, according to the strength of the acid and the length of time it is in contact with the cellulose. As a rule, only low nitrated products are obtained by the action of cold nitric acid alone, the preparation of the higher nitrates necessitating the employment of a mixture of strong nitric and sulphuric acids. The use of sulphuric acid facilitates the action of nitric acid by taking up the water produced in the reaction.

The best known cellulose nitrates are soluble pyroxylin and

gun cotton. The former is usually regarded as consisting of a mixture of the tri- and tetra-nitrates, $C_{12}H_{17}(NO_3)_3O_7$ and $C_{12}H_{16}(NO_3)_4O_6$, while gun cotton is considered to be a hexa-nitrate, and is represented by the chemical formula $C_{12}H_{14}(NO_3)_6O_4$. A solution of soluble pyroxylin in a mixture of alcohol and ether is known as collodion, and constitutes the raw material used in the manufacture of *Chardonnet silk*. Hot strong nitric acid completely decomposes cellulose with the formation of oxalic acid and other products. Hot weak acid yields cellulose di-nitrate $C_{12}H_{18}(NO_3)_2O_8$, as principal product.

Organic acids, such as *oxalic*, *citric*, and *tartaric*, have no appreciable action on cellulose under ordinary working conditions, provided that care is taken to remove all traces of acid from the treated fabrics before they are dried. It is considered that the tendering of cotton and linen goods, which sometimes occurs after they have been treated with oxalic acid and dried, is partly due to the disruption of the cell walls by the crystallisation of the acid within the fibres.

Acetic and formic acids have practically no effect on cellulose under any of the conditions which obtains in practice.

Behaviour towards Alkalies.—Solutions of *soap* or *ammonia* have no action on cellulose under any condition of practical work. Cotton is also unaffected by boiling solutions of *sodium carbonate*, although it is generally admitted that the use of the latter in excessive quantities in laundry washing operations causes a gradual degradation of those properties upon which the value of the fibre depends. This result is considerably influenced by the mode of carrying on the washing process, as well as by the length of time occupied, the strength of the solution, and the nature of the subsequent treatment to which the goods are subjected.

The yellowish tinge commonly exhibited by linen and cotton goods after washing, is more pronounced, as a general rule, in the case of goods which have been subjected to excessive treatment with sodium carbonate solutions. Weak boiling solutions of *caustic soda* or *potash* have no action on cellulose in absence of air; in presence of the latter, however, oxidation is induced, and long boiling under such conditions brings about a gradual tendering of the fibres.

Strong solutions of *caustic soda* have a profound action on cotton cellulose, each fibre undergoing a peculiar alteration. If a cotton fibre be focussed under the microscope, and a drop of caustic soda solution (50 deg. Tw.) introduced under the cover glass, it will be observed that the fibre loses its spiral form, changing to that of a nearly straight cylindrical tube. Its com-

paratively thin walls appear to swell out, thus causing the central canal to diminish to a mere line (Fig. 2). A transverse section exhibits a tube with a very small opening and comparatively thick walls. Cotton cloth treated with strong caustic soda solution contracts in area, becomes translucent, thicker, and stronger, these remarkable changes being first observed by John Mercer in 1844. Until a few years ago, however, the only practical outcome of the discovery was in connection with the production of crepon effects on cotton and mixed goods.

The most important development of the process—now universally known as *mercerising*—depends upon the fact that if cotton goods are prevented from contracting by mechanical means after

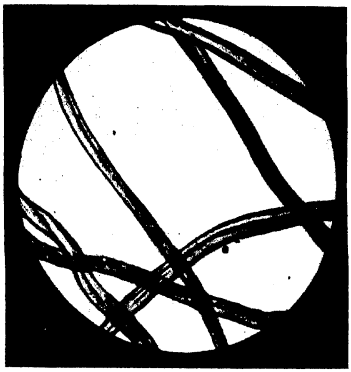


Fig. 2.—Mercerised Cotton. (× 120 diam.).

having being impregnated with caustic soda solution, and subsequently washed while in the stretched condition, they acquire a silky lustre. The same effect is produced by allowing the impregnated material to contract and then stretching to its original dimensions.

This peculiar behaviour of strong solutions of caustic soda towards cotton cellulose is due—according to Mercer—to the formation of a definite chemical compound of cellulose and caustic soda, to which the formula $(C_6H_{10}O_5)_2\ 2NaOH$ has been given. On washing with water, the alkali-cellulose is converted into a stable cellulose hydrate of the composition $(C_6H_{10}O_5)_2H_2O$. As a result of this change an increase in weight takes place, amounting to about 5 per cent., the theoretical increase, as calculated from the formula, being 4.5 per cent.

Mercerised cotton has a greater affinity for direct dyes than ordinary cotton. According to Lange, it can be readily distinguished from the latter by steeping for about three minutes in a solution of iodine in potassium iodide and zinc chloride, and then washing. Mercerised cotton becomes blue, while ordinary cotton remains unchanged. The solution is made as follows :—

SOLUTION A.

1 oz. iodine.
5 oz. potassium iodide, dissolved in
1 gill water.

SOLUTION B.

30 oz. zinc chloride
dissolved in
1 gill water.

Add solution A to solution B, shake well, allow the sediment to settle, and use the clear brown liquid.

Action of Oxidising and Reducing Agents.—The most important oxidising agents used by the launderer are solutions of *sodium hypochlorite* and *bleaching powder*. Either of these exerts a powerful disintegrating action on cellulose fibres under favourable conditions, with the formation of colourless oxidation products. Cold weak solutions have little effect upon cellulose, but they gradually decolourise many kinds of colouring matter with which it is frequently associated. If either of the solutions is allowed to concentrate on the fibre, however, *e.g.*, by drying without washing, tendering ultimately ensues. Long treatment of cotton or linen goods with weak solutions at an elevated temperature, causes a gradual weakening of the fibres, while disintegration of the fibre takes place with great readiness in presence of strong solutions.

The product of the excessive action of oxidising agents on cellulose is termed *oxycellulose*. It possesses a greater affinity for certain colouring matters, *e.g.*, methylene blue, than unchanged cellulose, and it also possesses strong reducing properties. In addition to solutions of sodium hypochlorite or bleaching powder, other oxidising agents, such as permanganate of potash, perborate of soda, chromic acid, etc., are capable of effecting the conversion of cellulose into oxycellulose. It is also considered that the tendering of window curtains and blinds is due to the formation of oxycellulose by the action of sunlight and air.

Reducing agents do not appear to have any action on cellulose under any condition of practical work.

LINEN.

Next to cotton, the most important vegetable fibre is flax, which is obtained from the bast portions of certain plants belonging to the genus *Linum*. When spun into yarn or woven into cloth it is known as linen.

The commonest species of flax is known as *Linum usitatissimum*, of the natural order *Linaceæ*. It is an annual, and appears to have been known four or five thousand years ago, the earliest records of the flax cultivator being found among the tombs of the ancient Egyptians. It is probable that the plant originated either in Egypt or in one of the sub-tropical regions of Asia, but at the present time the great flax-producing countries are situated in the temperate zone.

The stem of the plant is slender and erect; it attains a height of from 2 to 3 feet, with branches near the top, and is crowned with beautiful blue flowers. The flowers are succeeded by capsules containing dark brown seed, which form the raw material in the manufacture of linseed oil, linseed meal, and other products.

The flax is pulled up by the roots, and the long and short stems arranged in such a way that they can be readily separated. In some districts the stalks are next subjected to the operation of rippling, which has for its object the removal of the capsules containing the seed. In this operation the stalks are drawn by hand through the teeth of an instrument known as a ripple, which consists of a block of wood containing a number of iron prongs shaped like a comb.

Steeping or Retting.—One of the most important operations that flax undergoes before being placed on the market is known as the steeping or retting operation, and the quality of the ultimate fibre is largely dependent upon the skill with which this operation is carried out. If we take a stem of the flax plant and cut it across so as to obtain a transverse section, we may distinguish the following portions. The centre, which is occupied by pith; surrounding the latter is a layer of woody fibres; next to this is the inner bark or bast which consist of very long and tough fibres; adjoining the bast we find the outer bark covered by the epidermis.

The bast fibres are cemented together, and also to the adjacent portions of the stem of the plant by gummy and waxy substances, and the object of the steeping process is to separate the fibres not only from the woody parts of the stem but also from each other. In order to accomplish this, advantage is taken of the action of ferments, which, under suitable conditions, readily modify the gummy substances present in the stem of the plant

in such a way that the woody matter can be subsequently separated without much difficulty.

Steeping or retting processes may be divided into two classes, viz. :—Water retting processes and artificial retting processes. The first class includes three important methods by which the largest bulk of the world's supply of flax is produced, whilst the second class includes various chemical methods and those which depend upon the use of steam or hot water.

Retting in Still Water.—This process is employed in Ireland and to a considerable extent in Russia. It consists merely in steeping the bundles of flax in water contained in a natural ditch or dam, if possible near to a supply of water. The bundles of flax are covered with weeds, straw, sods, and stones, the object being to keep the flax beneath the surface of the water until gases cease to be evolved. About 10 to 11 days are required for retting flax by this method.

Retting in Running Water.—This method is carried on in running water, and is practised to a large extent in Belgium, especially in the Courtrai district. The flax straw which has been kept for one or two years is packed in wooden crates, which are submerged in a suitable stream and fastened to the bed by means of stakes. About ten days is the average time occupied in steeping by this method, but the hotter the weather, the shorter the time required to bring about the desired result.

Dew Retting.—Retting by simple exposure to atmospheric influences is carried on to a very large extent in Russia, where four million acres are under flax cultivation. It is obvious that this method will require a much longer time for its completion than those already enumerated, and as a rule several weeks are necessary. Dew retted flax is frequently discoloured and sometimes "spotted"; it has a dull rusty appearance.

The retting methods of the second class, such as chemical retting, and warm water retting, are carried on only to a limited extent. Special tanks are required in which the chemicals used, or the warm water, as the case may be, are placed, along with the bundles of flax. As a rule, retting under artificial conditions is complete in a much shorter time than under ordinary conditions, but such methods require more careful supervision.

Separation of Fibres from the Stems.—The dried retted flax is next passed between the fluted iron rollers of a breaking machine, in order to break the brittle woody portion of the stem into small fragments, the flexible fibres remaining uninjured. This operation is termed *breaking*, and is followed by *scutching*, the object of which is to remove the broken woody matter from the fibres. It is carried on by subjecting bundles of the flax straw

to the action of rapidly revolving wooden blades, the bundles of straw being held in such a position that the woody matter is rapidly beaten out. The scutched fibre is then taken in hand by the spinner, who subjects it to a number of mechanical operations, the objects of which are (*a*) to comb out and separate the entangled fibres, laying them smooth and parallel; (*b*) to transform the combed fibres into an endless band or "sliver," and (*c*) to reduce the thickness of the "sliver" by drawing it out to such a degree that a thread of the requisite "count" can be obtained by further attenuation and the introduction of the necessary amount of twist during spinning.

Physical Structure and Properties.—When a typical flax fibre is examined microscopically, it exhibits straight and more or less cylindrical cells with nodes at irregular intervals, while a central

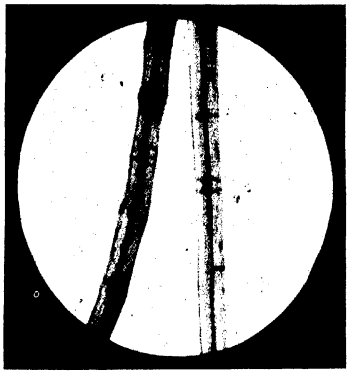


FIG. 3.—TYPICAL FLAX FIBRES. (× 120 diam.).

canal or lumen is readily distinguished (Fig. 3). A transverse section exhibits a number of well defined polygons, each showing a central opening. An individual flax cell varies in length from 20 to 40 mms.; consequently, the long fibres of combed or hackled flax line consist of a large number of cells aggregated together.

Flax contains on an average from 5 to 9 per cent. hygroscopic moisture. Its chief physical characteristics which distinguish it from cotton are its great strength, lustre, and the pure white colour it exhibits when fully bleached.

Chemical Composition.—Flax is generally regarded as belonging to the group of compound celluloses known as pecto-celluloses, but during bleaching the pectic constituents are removed and the bleached fibre consists essentially of cellulose.

No satisfactory method has yet been discovered for distinguishing, by chemical means, the cellulose of flax from the cellulose of cotton.

Impurities in Raw Flax.—Flax loses from 15 to 30 per cent. in weight during the bleaching processes, the substances extracted consisting chiefly of wax, pectic matter, and wood. It has been shown that the wax consists of a wax alcohol, which is only slowly attacked by alkalies, a property that renders its ready and complete removal from the fibres in an economical manner a problem of considerable difficulty. Pectic matters form the greatest bulk of the substances removed during bleaching.

Action of Chemicals.—The action of the more important chemicals used in laundry work on linen cellulose is much the same as on cotton cellulose, although it is generally admitted that the former is more sensitive to the action of acids, alkalies, and oxidising agents than cotton cellulose.

Solutions of *sodium carbonate* at 100 deg. C. have no immediate weakening effect on bleached linen, but prolonged and intermittent treatments are considered to be more or less injurious, especially if the solutions are strong. Weak solutions of *caustic soda* appear to act more energetically on linen than on cotton. According to Farrell and Goldsmith ("*Jour. Soc. Dyers and Colourists*," 1910, p. 199), a 2 per cent. solution of *caustic soda* at the boil produces a yellow colour on both fibres, although the same effect is not produced even with a 5 per cent. solution of *sodium carbonate* under like conditions. These authors also maintain that the production of the yellow colour is independent of the presence of air, for if the latter be excluded by leading hydrogen through the solution, or if air is bubbled through the solution, the discoloration in a single experiment is not noticeably different.

The fibres of linen which have been weakened by the excessive use of alkalies exhibit peculiar bulb-like swellings at irregular intervals. This characteristic appearance was first noticed by Pope, and later by Jackson. It was also noticed that the transverse markings frequently observable in normal fibres were scarcely discernible in damaged fibres.

Similar effects are exhibited by the fibres of cotton articles, which have been tendered by excessive treatment with alkalies, and all goods which have been damaged in this way give rise to a considerable amount of "lint" or "fluff."

Action of Sodium Silicate.—It is the general opinion amongst those authorities who have noted the results of using sodium silicate or washing powders containing this substance for cleansing the vegetable fibres, that, sooner or later, hot solutions exert

an injurious action, and the results of a series of careful experiments which has been carried out by several investigators appear to confirm this opinion. The authors referred to above, state that a hot dilute solution of sodium silicate in presence of hard water brings about the precipitation of silica in conjunction with calcium and presumably magnesium salts, if the latter happen to be present in the water, and it seems as if this statement holds good whether sodium carbonate is present or not. The precipitated matter is deposited on the fibres of the articles being washed, with the result that increased friction is set up, and the goods are gradually weakened.

In one experiment it was found that the weight of the ash of a fabric increased ten times after one washing with a silicate powder free from soap. In another experiment a silicate powder containing soap was used for twelve washes. The percentages of ash before and after the experiment are given in the following table :—

Material.	Per cent. of ash before washing.	Per cent. of ash after washing.
Linen	0·13	2·0
Cotton	0·06	2·2

The objection to the deposit of insoluble matter on the fibres is that it induces increased friction during the subsequent ironing operations, with the result that the fibres become brittle and easily break off, leaving the articles more or less threadbare. It was found that the development of brittleness was accompanied by a loss in tensile strength if the goods were subsequently ironed, but the loss was by no means proportionate. Leimdörfer states that the deposit caused by silicate of soda is easily washed out of cotton goods, but linen goods retain it, and ultimately gain in weight if repeatedly washed in pure sodium silicate solution. If soap is used, however, in conjunction with silicate of soda, the lather exerts a retarding influence on the deposition of silica and calcium salts on the fibres. The following tables ("*Seifensieder Zeitung*," 1908, pp. 279, 1271) give the results of several experiments carried out by Leimdörfer on the action of soap and sodium silicate solutions respectively on the tenacity and weight of cellulose articles of different textures :—

TWENTY WASHES IN MACHINE.
(Soap Solution.)

	Linen.			Cotton.
	Coarse.	Medium.	Fine.	
Loss of weight	3·5	4	6·2	4·2
Loss of tenacity	17·6	19·0	21·3	18·5

TWENTY WASHES IN MACHINE.

(Sodium Silicate Solution.)

		Linen.			Cotton.
		Coarse.	Medium.	Fine.	
1% $Na_2Si_2O_5$	Gain of weight	0.09	1·3	0·26	Loss of weight 11·4
	Loss of tenacity	25	26·1	28·4	Loss of tenacity 26·1
5% $Na_2Si_2O_5$	Gain of weight	0·32	1·61	0·73	Loss of weight 19·7
	Loss of tenacity	31·4	33·2	36·6	Loss of tenacity 3·32
10% $Na_2Si_2O_5$	Gain of weight	1·27	2·1	0·46	Loss of weight 17·54
	Loss of tenacity	38·6	40·2	39·1	Loss of tenacity 4[illegible]6.

Action of Acids.—Cold dilute mineral acids, *e.g.*, *sulphuric* and *hydrochloric acids* have practically no effect on the strength of the fibre under ordinary working conditions, but disintegration of the material takes place if such liquids are used hot or allowed to become concentrated. Cold or hot solutions of organic acids, such as *oxalic* and *tartaric acids*, have no action on the linen fibre under the usual conditions prevailing in the laundry. It is of great importance, however, that goods which have been treated with oxalic acid, should be thoroughly washed before drying, in order to prevent disruption of the cell walls by the subsequent crystallisation of traces of acid left in the fibres.

The use of hard water in conjunction with oxalic acid may cause a deposition of insoluble oxalates in the fibres of the articles undergoing treatment, with the result that a greater amount of friction is induced in the subsequent finishing processes than in the case of goods which are not contaminated with insoluble inelastic matter.

Oxidising agents, such as solutions of *bleaching powder* and *sodium hypochlorite*, exert a disintegrating action on linen under favourable conditions. Weak solutions have no apparent effect if allowed to act for a short time only, and if used at the ordinary temperature, but too long a treatment or the use of warm solutions, is liable to cause tendering, especially in the absence of oxidisable matter other than the fibres. Strong solutions act very energetically, especially if warm, the fibre being gradually converted into oxycellulose.

JUTE.

This fibre forms the bast portion of various species of *Corchorus*, the most important being *Corchorus capsularis*. It is a native of India, and is cultivated to a very large extent in the north and north-east of Bengal.

The plant is an annual, attaining a height of 5 to 10 feet, and the fibre is separated from the woody matter, etc., by similar processes to those employed for the separation of flax. As a rule,

the stems are packed in crates, and the latter placed in a sluggish river. Fermentation begins very readily, and after a few days the bark separates from the stem. The straw is then removed by a stripping process, and the fibres separated, well-washed, and dried.

Raw jute fibre has a length of from 1½ to 2½ yards long, but about 12 inches of the root end is cut off before being spun into yarn; these cuttings, which are known as jute "butts," are used for making paper.

The remaining portion of the fibre is softened by a treatment with an oil emulsion, and is subsequently hackled and spun into yarn. Jute is largely employed in the manufacture of sacking, ropes, and carpets. Just as in the case of flax, the bast cells of jute are very small, varying from 1.5 to 5 mms. in length; consequently, a raw fibre of commerce is made up of innumerable fibrillæ cemented together to form one long continuous fibre.

Jute does not possess any characteristic appearance when examined under the microscope. The fibres are perfectly straight, and usually covered with fine longitudinal markings.

A transverse section of a fibre exhibits a number of cells—usually pentagonal or hexagonal in shape—which appear to be bound together by a translucent substance. Each cell shows a relatively large central opening.

Chemical Composition.—According to Cross and Bevan, jute does not contain free cellulose, but consists of a substance termed bastose, combined with oxidised cellulose, to which the name corchoro-bastose has been given. It belongs to the group of celluloses known as ligno-celluloses, and as a rule is more readily attacked by chemicals than other vegetable fibres. Jute materials are seldom dealt with in the laundry. On treating with chlorine, the fibre is converted into a chlorinated product, which in presence of sodium sulphite gives rise to a crimson colour.

CHINA-GRASS, RAMIE, OR RHEA.

This fibre constitutes the bast portion of *Boehmeria nivea*, which belongs to the nettle family. It is chiefly grown in China, India, and the Eastern Archipelago.

The fibre is separated from the green stems by hand or machine, the process being termed decortication. Retting processes are inapplicable, as the outer bark of the plant is cemented to the bast fibres by a pulpy substance which cannot be readily resolved by fermentative processes into simpler substances without injuriously affecting the fibres. The best hand decorticated fibre still retains about 20 to 25 per cent. of gummy and other impurities, and considerable difficulty is experienced in removing

the gum after it has become dry. Many processes have been introduced for effecting the mechanical separation of the fibres from the dry stem and bark, but few of these appear to have met with much success.

Ramie is easily bleached, and the purified fibre consists of cellulose. Goods made of China-grass, or those containing effect threads of the material, may be treated in the laundry in the same way as linen, but excessive friction should be avoided.

China-grass may be distinguished from cotton and linen by its appearance under the microscope (Fig. 4), and by means of its characteristic physical properties.

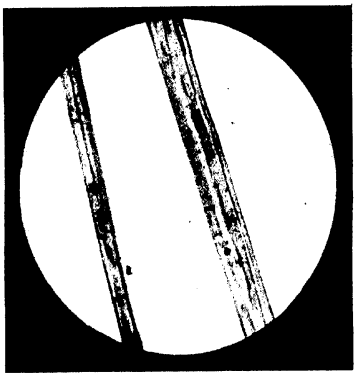


FIG. 4.—CHINA-GRASS. (× 120 diam.).

SECTION II.—ANIMAL FIBRES.

WOOL.

This fibre is usually regarded as the hair of the sheep, but the hair of certain goats, such as Cashmere, Mohair, alpaca, and the hair of the camel are generally classed under the same term.

Wool from different animals varies considerably in quality, and even the fleece of any one animal may be separated into portions of varying degrees of fineness, length, lustre, etc. The separation of wool into the various qualities is carried out by hand, the operation being known as wool-sorting. A considerable quantity of wool is produced in the United Kingdom, but British manufacturers are dependent chiefly upon Australia, New Zealand, Tasmania, and Cape Colony for the bulk of their wool supply.

The length of the wool fibre—*i.e.*, a lock or strand pulled from the bulk—is known as its staple, and we may distinguish between long-stapled wool (over 1½ ins. long), and short-stapled wool. The diameter of the fibre is proportional to its length. Long-stapled wool is generally combed and subsequently spun into *worsted* yarn, whilst the shorter qualities are carded and finally spun into *woollen* yarn. Worsted yarn is used for the manufacture of the best qualities of coatings, ladies' dress goods, etc. Woollen yarn is used principally in the production of goods which are subjected subsequently to a fulling or felting operation in order to impart a thicker and fuller handle to the fabrics.

Botany Wool.—This is the general name given to the finer varieties of merino and crossbred wools which are imported from Australia and Cape Colony.

Home Grown Wool.—This may be roughly classified as coarse and long-stapled lustre wool. Home-grown wools are used chiefly in the manufacture of specialities.

Cashmere.—This variety is obtained from the cashmere goat, which is found in the hilly regions of Cashmere and Tibet. The hair of the goat frequently attains a length of 18 inches.

Mohair is the hair of the Angora goat, and is imported in very large quantities, chiefly from Cape Colony and Turkey. It possesses a high lustre, and is used principally in the manufacture of ladies' lustre dress fabrics.

Alpaca is obtained from an animal belonging to the Camel family of the same genus as the Llama. The Alpaca goat is a native of the Andes, being found chiefly on the high mountains of Peru and Chili. Alpaca was first introduced into England by Sir Titus Salt, and is now used in large quantities for the manufacture of shawls, light cloths for warm climates, linings, etc. The hair is very soft and elastic, and varies in colour, being sometimes grey, sometimes yellowish brown, and occasionally almost black.

Physical Structure and Properties.—A careful microscopical examination of a typical wool fibre reveals three portions, viz. :—1. Flattened outer horny scales; 2. A middle portion consisting of fibrous shaped cells, and, 3. A central cavity filled with cells of more or less globular shape. The outer scales are funnel-like in shape and overlap each other, thus causing the fibre to exhibit a serrated appearance. It is generally recognised that the dimensions, uniformity, and compactness of the outer scales determine the lustre and strength of the wool.

Wool differs from the vegetable fibres in that it possesses certain important physical properties, which are not possessed by the former. It also possesses greater elasticity and strength and is more lustrous than the vegetable fibres.

Curliness and the property of becoming felted under certain conditions are properties peculiar to wool. The latter property is distinctive of wool and allied fibres, and has been utilised from very early times for the production of felted fabrics by subjecting wool, in the presence of water, to friction and pressure, which cause the outer scales of one fibre to become interlocked with the scales of another. Large quantities of wool are felted for the manufacture of hats, slippers, saddles, etc. It has been found that wool which possesses well developed outer scales and considerable elasticity is most suited for the process. Felting or fulling is carried on with the aid of special machinery, and generally in a warm and slightly acid or alkaline solution.

The shrinkage which frequently takes place during the washing of woollen garments in the laundry is due to a partial felting of the fibres, and it is common knowledge that hot alkaline

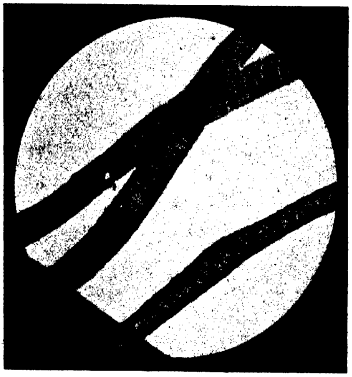


FIG. 5.—TYPICAL WOOL FIBRES. (× 120 diam.).

liquors cause a greater shrinkage than warm slightly alkaline, or neutral liquors, the degree of shrinkage also varying with the amount of friction employed.

Hygroscopic Moisture.—Wool absorbs about 14 per cent. of moisture under ordinary conditions and retains it very tenaciously. Under abnormal conditions, *e.g.*, in a damp atmosphere, it will absorb as much as 50 per cent. of moisture without feeling wet.

Action of Heat on Wool.—When wool is dried at a temperature of 120 deg. F., it loses from 7 to 10 per cent. of its hygroscopic moisture, and if drying takes place at 212 deg. F., a further loss of 5 to 8 per cent. occurs. After drying at 120 deg. F., the wool will again absorb moisture up to the original amount, but if dried at 212 deg. F., only part of the original moisture is regained

on exposure to the air. This seems to show that wool undergoes a peculiar alteration if heated at 212 deg. F. for some time, and it is well known among dyers and launderers, that the drying of woollen materials at high temperatures results in the destruction of some of the most important properties of the fibre, rendering it brittle, devoid of lustre, yellowish in colour, and considerably reduced in strength and elasticity.

Wool becomes more or less plastic when placed in water at 100 deg. C., or when subjected to the action of steam, and the shape it attains under such conditions is retained on cooling. Certain important finishing processes are dependent upon this property.

Chemical Composition.—Wool differs from other textile fibres in that it contains the elements nitrogen and sulphur in addition to carbon, hydrogen, and oxygen. Silk also contains nitrogen but no sulphur, while most of the purified vegetable fibres contain only the three elements—carbon, hydrogen, and oxygen. The substance of purified wool fibre is termed *keratin*, and is closely allied in chemical composition to the members of a class of substances known as proteids or albuminoids, of which class egg albumen is a typical representative. All proteids contain the five elements C, H, O, N, and S, as well as a small amount of mineral matter. A table is given below in which the figures obtained by the analyses of wool and albumen are compared:—

Comparison of Analyses of the Wool Substance and Egg Albumen.

	Wool Substance (Bowman).	Egg Albumen.
C	50·8	51·48
H	7·2	6·76
O	21·2	22·66
N	18·5	18·14
S	2·3	0·96
	100·0	100·00

The amount of sulphur in wool varies considerably (from about 2 to 4 per cent.), and according to Chevreul it appears to be of two kinds, one of which may be removed by long treatment with weak alkalies, while the other seems to be unaffected. Many of the stains contracted by woollen articles in the laundry are caused by contact with metals, which under suitable conditions are capable of forming coloured sulphides with the sulphur in the wool.

The presence of sulphur may be readily demonstrated by placing a piece of white wool in a solution of plumbite of soda contained in a boiling tube, and gently warming the solution. In

a few seconds the wool acquires a brownish colour, which finally becomes almost black. *Plumbite of soda is made by slowly adding caustic soda solution to a solution of lead acetate until the precipitate first formed is just redissolved on boiling the mixture.*

Action of Acids.—The effect of dilute acids, such as *acetic, formic, hydrochloric, sulphuric,* etc., on the wool fibre is practically negligible even at an elevated temperature. Strong *sulphuric, nitric,* and *hydrochloric acids,* bring about complete disintegration of the fibre more or less rapidly. Weak hot *nitric acid* imparts a yellow colour to the fibre.

Action of Alkalies.—Wool differs from the vegetable fibres in being very readily attacked by alkalies, the ultimate effect being dependent upon the nature of the alkali, strength of solution, and temperature. Weak solutions of *sodium* or *potassium carbonate* have little effect on the fibre if used at a low temperature, but exercise a destructive action at elevated temperatures. Wool is completely disintegrated if boiled for some time in a comparatively weak solution of *sodium carbonate.*

Weak solutions of the *caustic alkalies* exercise a powerful destructive action even in the cold, while at the boiling point dissolution takes place more or less readily.

Ammonia, solutions of *neutral soaps,* and *borax,* are generally used in the laundry for cleansing woollen articles as they do not appear to exercise an injurious action on the fibre under ordinary working conditions.

Action of Oxidising and Reducing Agents.—Solutions of *bleaching powder* and *sodium hypochlorite* have an injurious action on wool, causing it to become harsh, and yellow. Consequently, they cannot be used for bleaching purposes, although they are employed for chlorinating certain kinds of yarn, in order to render the manufactured goods unshrinkable. They are also used in the preparation of woollen goods or unions, which have to be subsequently printed with thickened solutions of dyes. The chlorinated fibre exhibits a better lustre than untreated wool, and has a greater affinity for dyes. The latter property was first noticed by John Mercer, who experienced considerable difficulty in obtaining the same shade of colour in the printing of cotton and woollen unions —*i.e.*, delaines.

A solution of *permanganate of potash* readily oxidises the colouring matter of wool, the product being colourless. It is sometimes employed for bleaching woollen articles, and in such cases the bath should be rendered acid by the addition of a small quantity of sulphuric or hydrochloric acid. After treatment, the wool is washed and then placed in a bath of sulphurous acid in order to remove the precipitated hydrated oxide of manganese.

Ordinary reducing agents, such as *sulphurous acid,* and *sodium hydrosulphite,* exercise a decolourising action on the yellowish colouring matter of wool, the former being largely used for

"stoving" certain kinds of manufactured goods. In "stoving," the articles in the moist condition are hung in a suitable chamber or "stove," and exposed to the action of sulphur dioxide gas, which in presence of moisture forms sulphurous acid.

The colourless reduction product or products formed by the action of sulphurous acid on the colouring matter of wool, appears to be readily decomposed, the original colour of the wool gradually reappearing on exposing the goods to atmospheric influences for a comparatively short time, while weak alkaline solutions, such as are used in washing operations, facilitate their decomposition.

SILK.

By the term *silk* is meant the fibrous substance produced by various species of the silk worm for the purpose of forming nests or "cocoons," in which they pass the chrysalis stage of their existence.

The true silks of commerce may be divided into two classes, viz. :—1. Those produced by worms reared under artificial conditions, and 2. Those varieties produced by worms which are found in the forests of India, China, and Japan. The best known and most important variety belongs to the first class, and is produced by the mulberry silkworm, *Bombyx mori*, large numbers of which are reared in Southern Europe, China, India, and Japan. In Europe the eggs are hatched in specially constructed buildings in which the temperature can be easily regulated. After hatching, the young insects are systematically fed on the leaves of the mulberry tree. At the end of about a month the worms become restless, and cease to feed. At this stage they are placed on birch twigs, where they "spin" their cocoons. "Spinning" lasts about three days. The cocoons are then collected, and those intended for the market are subjected to the action of steam in order to kill the worms.

The silk substance utilised by the worm in "spinning" its cocoon is secreted by glands symmetrically situated on either side of the body, and communicating with each other by means of a capillary tube with a fine orifice in the head of the worm, known as the "spinneret." On coming in contact with the air the two gelatinous fibres solidify and become cemented together along their length.

In order to get a relatively strong thread several fibres are reeled into one, the process being carried out by placing a number of cocoons into water at a temperature of about 60 deg. C., so as to soften the gummy substance which binds the fibres together, and then reeling a greater or less number of fibres into a single thread of raw silk.

Organzine or warp silk is prepared by twisting together

about 12 to 18 of the imported raw silk threads. Weft or *tram* silk contains a less number of threads as well as less twist.

The cocoons which have been spoilt owing to one cause or another, are thoroughly cleansed first with water, and then with a weak solution of sodium carbonate. Finally the purified silk is carded and subsequently spun into yarn. Silk treated in this way is known as *spun silk*.

Physical Structure and Properties.—Raw silk is of a cream or yellowish colour, and exhibits little lustre. A single fibre obtained from a cocoon varies in length from 500 to about 1,500 yards, and in diameter from 0.01 to 0.02 mms. Its specific gravity is almost 1.4. When a single fibre is examined under the microscope it exhibits the appearance of two straight transparent stick-like fibres, cemented together along their entire length (Fig. 6). The fibre is completely devoid of cellular structure.

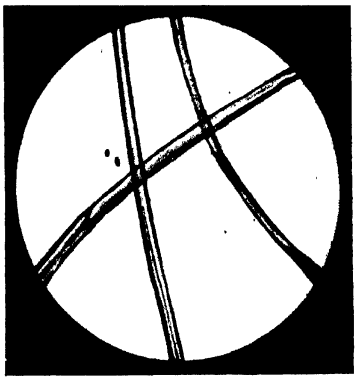


Fig. 6. - Raw Silk. (× 120 diam.).

On boiling with soap solution the outer covering of cementing material is removed, and each pair of fibres becomes separated, the high gloss so characteristic of silk being developed at the same time. This process is termed "boiling-off," the treated fibre being known as "boiled-off" silk.

Silk possesses many important physical properties which render it of the utmost importance in the manufacture of textile materials. As regards lustre and strength, it is pre-eminent among natural fibres, and in common with wool, it possesses a high degree of elasticity. Silk is heavier than water, in which it is insoluble, and as it lacks the power of readily conducting elec-

tricity, great care has to be exercised in textile factories, owing to the danger of fire.

Bombyx mori silk will absorb as much as 30 per cent. of moisture without feeling wet, and owing to its expensive nature, conditioning houses have been established in many industrial centres for the purpose of determining its hygrometric condition whenever required. The legal amount of moisture allowed is 11 per cent.

Chemical Composition.—A fibre of raw silk consists essentially of an inner portion which is known as *fibroïn*, and an outer portion termed *sericin*, or *silk gum*. Fibroïn constitutes the fibre proper, while sericin or silk-gum consists of a thin outer covering or sheath, which, as previously mentioned, is removed by weak alkalies in the boiling-off operation. From a consideration of the behaviour of fibroïn and sericin toward various reagents, it is concluded that they are different chemical substances, and careful chemical analyses have yielded results which correspond to the following formulæ:—Fibroïn, $C_{15}H_{23}N_5O_6$, and sericin, $C_{15}H_{25}N_5O_8$.

It will be seen that fibroïn differs from purified vegetable fibres in that it contains nitrogen, and it may be readily distinguished from wool and hair owing to the absence of sulphur. The silk fibre behaves in many respects like the proteids.

Action of Acids.—Weak acids are absorbed by silk and are completely removed only with difficulty. Silk is frequently treated in finishing operations with a weak solution of *acetic*, *sulphuric*, or *tartaric acid*, for the purpose of enhancing the lustre and developing a peculiar rustling sound known as "scroop." Hot weak mineral acids have a destructive action on the fibre, while strong acids readily dissolve it. Warm dilute *nitric acid* imparts a yellow colour to the fibre, and this is changed to orange by subsequent treatment with alkalies.

Action of Alkalies.—Silk is readily acted upon by alkalies, but not so energetically as in the case of wool. Weak solutions of *caustic soda* have no pronounced action in the cold, but act injuriously on the fibre at an elevated temperature. At the ordinary temperature silk may be printed with thickened caustic soda solution of a strength equivalent to 20 deg. Tw., without any appreciable destructive action taking place. Moderately strong hot solutions, however, completely dissolve the silk.

As a general rule, hot weak solutions of the *alkali-carbonates* have very little injurious action on the silk fibre, but strong hot solutions are destructive.

Ammonia and *soap solutions* have no appreciable action under the conditions which prevail in the laundry.

Action of Oxidising Agents.—Strong solutions of *sodium* or *calcium hypochlorite* attack silk and ultimately destroy it; very

weak solutions have no immediate injurious action, but they appear to alter the nature of the fibre in such a way as to cause it to have a greater affinity for colouring matters.

Strong solutions of *permanganate of potash* exercise a disintegrating action on the fibre, but weak solutions containing a little acid are often used for bleaching purposes. The best bleaching agent for silk, however, is hydrogen peroxide.

Behaviour towards Solutions of Metallic Salts.—Silk readily absorbs many metallic salts from cold moderately strong solutions, and this property is utilised in the weighting of silk. Weighted silk goods which have been worn for some time are very easily tendered, and need to be treated with the greatest care in the cleansing processes, especially if they are contaminated with perspiration stains.

Wild Silks.—The varieties of silk belonging to the second class are generally termed wild silks. A very large number is known, but the only one which appears to be used on a large scale is *Tussah* or *Tussore Silk*. It is the product of the silk moth *Antherea myllita*, and is usually imported in the spun condition from India and China. The cocoons are found in masses attached to trees in the jungle. They are much larger than those produced by the Bombyx mori silkworms. The fibre is double, possesses great strength, and is of a brownish colour. It is much coarser than Bombyx mori silk and possesses much less lustre. Under the microscope, Tussah silk appears as a double flat transparent fibre, each fibre consisting of a number of fibrillæ.

Action of Chemicals.—Tussah silk differs from ordinary silk in its behaviour towards chemical reagents. Alkalies and acids attack it with difficulty, weak boiling solutions having little or no effect. Strong solutions, however, cause a gradual disintegration of the fibre. The brown colouring matter associated with the silk can only be bleached with difficulty.

SECTION III.—ARTIFICIAL FIBRES.

To the third class of fibres belong the different varieties of silk prepared by artificial means. The most important of these are manufactured from wood pulp cellulose, although other raw materials have been used from time to time. The fundamental principles underlying all methods of manufacturing artificial silk from wood pulp are essentially the same. In the first place a solution of cellulose of sufficient viscosity is prepared. Secondly, this is forced through fine orifices into a coagulating medium; and, in the third place, the fibres thus obtained are reeled into threads. The best known commercial varieties of artificial silk are termed Chardonnet, Glanzstoff, and viscose silk respectively.

Chardonnet Silk.—This is prepared by nitrating cellulose with a mixture of nitric and sulphuric acids and dissolving the product in a mixture of alcohol and ether. The solution is then forced through fine jets into a suitable medium, so as to precipitate the nitrated cellulose in the form of endless fibres, which are immediately reeled into threads. Artificial silk made from nitrated cellulose is very inflammable, and on this account it is customary to "denitrate" it by agitation in ammonium sulphide, weak nitric acid, etc., before it is sent into commerce. This variety is being gradually displaced by those mentioned below.

Glanzstoff.—This product is prepared by dissolving cellulose in ammoniacal copper hydrate, and proceeding as above. It differs from the latter in that it is not so inflammable, and when prepared by Thiele's process, is said to be almost indistinguishable from natural silk. According to Dreaper ("*Jour. Soc. Dyers and Colourists*," p. 8, 1907), it is possible to produce individual threads containing as many as eighty filaments, whereas a natural silk thread of the same size only contains about 7 to 9 filaments.

Viscose Silk.—The preparation of artificial silk from viscose has been carried on successfully for some considerable time. Wood pulp is the raw material, which is first impregnated with strong caustic soda and pressed; the alkaline material is next subjected to the action of the vapour of carbon disulphide for several hours, when a new product is formed which is believed to be a cellulose xanthate, the term viscose having been given to it by its discoverers, viz.:—Cross, Bevan, and Beadle. The product dissolves readily in water, yielding a viscous liquid from which the cellulose is precipitated in continuous threads by forcing the solution through jets into a solution of common salt or alcohol.

Solutions of cellulose in other reagents have been suggested for the preparation of artificial silk. The use of acetates of cellulose for the same purpose does not appear to have passed much beyond the experimental stage.

Goods containing artificial silk effects are not often treated in the laundry, but whenever such effects are met with, the greatest care should be exercised during the washing operation. Lukewarm or cold cleansing liquors are desirable, and the operation should be completed as quickly as possible. As a general rule, it is best to subject such goods to a dry cleaning process. Artificial silk is much more lustrous than natural silk. Hence, it can usually be distinguished from the latter by mere inspection.

CHAPTER II.

Materials Used in Laundry Work.

The materials used by the launderer may be classified as follows:—

1. Washing, scouring, or detergent substances.
2. Souring agents.
3. Whitening agents.
4. Finishing compounds.
5. Miscellaneous substances.

SECTION I.—WASHING MATERIALS.

To the first class of substances belong soap, washing soda, "alkali," ammonia, silicate of soda, caustic soda, and a few other detergents of minor importance. Of these, soap is universally employed, and constitutes the most important cleansing agent used in the laundry industry. The various forms of sodium carbonate are also generally used; ammonia is chiefly used for woollen and silk goods, while silicate of soda is a common constituent of "washing powder" or "lessives," which are used to a considerable extent on the continent. Caustic soda finds only a limited application in the laundry industry of this country, although it is often employed in American practice.

Borax, soap-bark, etc., are rarely employed alone, but they are commonly used in the manufacture of many of the proprietary "lessives" which are on the market.

Soap.—Ordinary soap is the chief product obtained by the action of a solution of caustic soda or caustic potash on vegetable and animal oils and fats. The latter substances belong to a class of chemical compounds termed glycerides, which consist of fatty acids, combined with glycerine.

When a glyceride is boiled with a solution of caustic soda or potash, chemical action takes place, with the result that the fatty acid of the glyceride forms a salt of soda or potash—*i.e.*, soap, and glycerine is liberated.

The chemical change which takes place in this important reaction, may be represented by means of the following equation, in which tallow is regarded as consisting of the glyceride known chemically as tristearin:—

$$\left.\begin{matrix} C_{17}H_{35}\cdot COO \\ C_{17}H_{35}\cdot COO \\ C_{17}H_{35}\cdot COO \end{matrix}\right\rangle C_3H_5 \left\langle\begin{matrix} OH \\ OH \\ OH \end{matrix}\right. \left.\begin{matrix} Na \\ Na \\ Na \end{matrix}\right\rangle = \left\{\begin{matrix} C_{17}H_{35}\cdot COO\ Na \\ C_{17}H_{35}\cdot COO\ Na \\ C_{17}H_{35}\cdot COO\ Na \end{matrix}\right. + C_3H_5 \left\langle\begin{matrix} OH \\ OH \\ OH. \end{matrix}\right.$$

Tallow or tristearin + caustic soda = soap or sodium stearate + glycerine.

f the free fatty acid known as stearic acid were used instead of he compound which it forms with glycerine, *i.e.*, tristearin, the ollowing reaction would occur:—

$$C_{17}H_{35}\cdot COO \vdots H + OH \vdots Na = C_{17}H_{35}\cdot COO\,Na + H_2O.$$

Stearic acid + caustic soda = soap or sodium stearate + water.

This reaction may be compared with the simple change which takes place on neutralising hydrochloric acid with caustic soda, as represented by the following equation:—

$$Cl \vdots H + OH \vdots Na = NaCl + H_2O.$$

We see from the second equation given above that only soap and water are formed when a free fatty acid is treated with an alkali. Furthermore, chemical action takes place more readily than when an oil or fat is used, but the free fatty acids are generally found in nature in combination with glycerine. Hence, they have to be prepared from the fats and oils whenever required; and if it were necessary, when making soap, to first of all prepare and isolate the fatty acids, and subsequently to neutralise them by means of alkalies, the cost of the process would be considerably enhanced.

In some cases, however, notably in the manufacture of candles, and in the distillation of recovered grease, free fatty acids are obtained in considerable quantity, and these are largely employed in soap making.

When an oil or fat has been completely converted into soap, the oil or fat is said to have been *saponified*, and the process of boiling with caustic soda or potash is called a saponification process.

Only vegetable and animal oils and fats are capable of forming soaps—*i.e.*, they are saponifiable.

Lubricating oils are usually derived from mineral sources and are unsaponifiable; therefore, mineral oil stains on textile fabrics cannot be readily removed by acting on them with a solution of caustic soda or sodium carbonate.

Commercial soaps are distinguished as "hard" or soda soaps, and "soft" or potash soaps, according to the particular alkali which has been used in the process of manufacture. When caustic soda is employed, the soap obtained is hard, while the soaps made with caustic potash are invariably of a soft nature.

The most important varieties of soap for laundry work are known as "white curd" and "mottled curd." The latter derives its name from its peculiar mottled appearance, which is caused by some of the impurities remaining in the interstices. Ultra-

marine and manganese dioxide are used for colouring purposes in the manufacture of blue, and grey mottled soaps respectively. White curd soaps are generally made from a mixture of tallow and a greater or less proportion of cocoanut oil, bleached palm-oil, or cotton-seed oil. Bone grease and kitchen fat are commonly employed in the manufacture of mottled curd, while a proportion of resin is frequently used in the preparation of certain brands of both varieties. Although resin is not a glyceride, it possesses the property of forming a soft soapy mass when boiled with alkalies. The product is commonly known as "resin soap," and is readily soluble in water. Brown or "black" soaps are also used in the laundry to a considerable extent. They are made principally from "olein" or recovered grease, and frequently contain considerable quantities of unsaponifiable matter. They are much valued on account of their excellent detergent properties. Olive oil is largely used in the manufacture of "olive oil soaps," which are invaluable for washing woollens and silks, as well as coloured goods. Many varieties of so-called "olive oil soaps," however, are made from cheaper oils and coloured to imitate the real article. The use of tallow alone, in the manufacture of a curd soap results in the production of an exceedingly hard variety, which, not being readily soluble in water, possesses weak lathering properties. If tallow is used in conjunction with resin or cocoanut oil, however, a softer soap is obtained, and it is well known amongst manufacturers that such a soap is more readily soluble in water, than a pure tallow soap, while it is also cheaper to produce.

It is a matter of common observation that the solubility of a soap is intimately associated with its lathering properties, for it is generally found that a soap which is comparatively difficult to dissolve does not lather so readily either in "hard" or "soft" water as a more soluble soap.

From these statements it will be evident that the lathering property of a soap is considerably influenced by the nature of the raw materials used in its manufacture. Not only does the use of certain oils and fats favour the production of readily soluble soaps, but the solubility—and consequently the lathering property—may be further increased by replacing some of the caustic soda with caustic potash.

Manufacture of Soap.—There are two principal methods by which most commercial laundry soaps are made, these being known as the boiling process and the "cold" process respectively. The boiling process of making hard curd soaps on a large scale is carried out as follows:—The oil or fat is first heated in a large pan provided with open and closed steam pipes, and a solution

of caustic soda added gradually. The pasty mass which first forms, consists essentially of partially formed soap with which is incorporated a considerable amount of water and glycerine. Further boiling and the addition of more caustic soda is necessary, in order to bring about a more effectual conversion of the oil or fat into soap. As soon as the chief boiling process is finished, the contents of the pan are subjected to an operation known as "graining," which depends upon the fact that soap is insoluble in a solution of common salt. A strong brine is therefore prepared and added to the pasty mass, which, after standing for some time, separates into two layers, the soap floating on top of the diluted brine and glycerine. The lower layer is then run off and the soap boiled up again with a weak solution of caustic soda, so as to effect the complete conversion of the last traces of oil or fat into soap.

The "finishing" of the soap is a kind of cleansing process; it consists of various treatments with water or weak caustic soda solutions, the mass being allowed to stand after each treatment, whereby the impurities separate and are subsequently removed. The purified soap is then boiled again until the soap maker judges the operation to be complete; finally it is run into frames and allowed to cool.

Soap which has been separated according to the above process is said to have been "salted out."

Large quantities of soap for scouring purposes are made from various oils and fats, and caustic soda, by the "cold" process, which differs from the boiling process in that the "salting out" operation is omitted; consequently, a greater or less amount of glycerine and water, as well as other impurities, remain incorporated with the soap.

The chief oils used in the "cold" process comprise palm oil, cotton-seed oil, castor oil, olive oil, and linseed oil. Another oily substance which is used to a large extent is known as "olein" or "oleic acid." This substance constitutes the red oils obtained as a bye-product in the manufacture of candles from tallow and palm oil. "Olein" consists chiefly of a mixture of free fatty acids, and readily forms a soap when neutralised with caustic soda or caustic potash. The carbonates of soda and potassium are also used in the manufacture of soap from "olein."

"Soft" or potash soap is frequently employed in the laundry. It is generally prepared from linseed oil, cotton-seed oil, or "olein," or from mixtures of these, the alkali employed being caustic potash, either with or without a small quantity of potassium carbonate. The ordinary soft soaps of commerce usually contain a considerable amount of water and free alkali as well as

the glycerine liberated during saponification. They are very serviceable for the treatment of coarse and greasy cotton and linen *goods when the latter are washed by machine.* Although a slight excess of free caustic soda or potash in a soap used for the mechanical washing of linen and cotton, is allowable, it is very important that such soaps should not be used in cases where hand washing is carried on, for the presence of even a very small quantity of free alkali in a soap solution, readily exerts a deleterious action upon the hands of the operatives. In such cases a neutral or superfatted olive oil soap should be employed.

Great skill and experience are necessary in the manufacture of the best varieties of soap, although there are many kinds suitable for certain branches of laundry work, which can be made without much difficulty.

It will be found, however, that the manufacture of soap in the laundry offers no advantages, because, as a general rule, soap can be purchased at a cheaper rate than that at which it can be made on a small scale.

We give below a few recipes for the manufacture of various soaps by the cold process, which is best adapted for making small quantities at a time.

No. 1 Soap.

75 lbs. cocoanut oil.
25 lbs. bleached palm oil.
44 lbs. caustic soda solution (70 deg. Tw.).
5 lbs. caustic potash solution (70 deg. Tw.).

Place the oils in an iron vessel provided with a mechanical agitator and a closed steam coil; raise the temperature of the mixture to about 100 deg. F., and then add the caustic soda and potash gradually with constant agitation. As soon as the ingredients have been thoroughly incorporated, the mass may be run into low flat vessels termed "frames," each having a capacity of from 1½ to 2 cwt.; the "frame" should be made in three pieces, viz.:—(1). The bottom piece. (2). The sides; and (3). The top. The first-named is grooved near the edges, so as to receive the sides, which are bolted together. The top is merely a covering of wood. In order to prevent the soap sticking to the sides of the "frame," it is customary to line it with wet cloth, prior to the introduction of the soap. If only a small quantity of soap is being made, it may be left in the pan. In either case, the containing vessel should be covered with sheeting, and the soap allowed to stand for several days in order to make sure that all action is over. It is then ready for use. If the soap has been "framed," one side of the "frame" is first removed, the remaining sides being then

easily detached. The following ingredients may be used in place of those given above:—

No. 2 Soap.

50 lbs. cocoanut oil.
25 lbs. cotton-seed oil.
25 lbs. kitchen fat.
50 lbs. caustic soda solution (70 deg. Tw.).

No. 3 Soap.

50 lbs. cocoanut oil.
25 lbs. palm oil.
25 lbs. tallow.
40 lbs. caustic soda solution (70 deg. Tw.).
10 lbs. caustic potash solution (70 deg. Tw.).

Soaps made according to the above recipes may be used both in the "first" and "second suds" for cleansing ordinary articles, but as they usually contain excess of free alkali, it is advisable to give the goods a subsequent rinse in a weak acid, followed by a thorough rinsing in water. For general work, however, they should be used in the "first suds" only, while a good quality of curd soap should be employed in subsequent operations.

Well made potash or soft soaps, practically free from uncombined caustic potash, are sometimes employed in the laundry for washing special articles. The best kinds of these soaps are made by the boiling process, but in many cases, "cold process" potash soaps are very satisfactory. According to W. J. Menzies, a good potash soap suitable for washing woollen goods can be made by using the following ingredients:—

50 lbs. powdered caustic potash free from carbonate.
5 gallons of water.
200 lbs. Gallipoli olive oil.

The potash is dissolved in the water and the solution cooled. It is then added gradually to the oil, which is contained in a vessel of suitable capacity. Thorough stirring is essential, and when the whole of the alkali has been added, the vessel is covered and put in a warm place for a few days. The above quantities give an almost neutral soap. Other oils may be used with advantage in place of olive oil, *e.g.*, linseed oil, cotton-seed oil, lard oil, etc., or mixtures of these.

Commercial "olein" is another raw material which is of special value in making small quantities of soap. Good results are obtained on boiling it with the requisite amount of sodium or potassium carbonate. For an "olein" potash soap about 25 to 30 lbs. of potassium carbonate are required for every 100 lbs. "olein," while the same amount of "olein" requires about 20 to 25 lbs. sodium carbonate for the production of a soda soap.

Valuation of Soap.—A complete and accurate analysis of a sample of soap is frequently a matter of considerable difficulty, and especially is this the case when reliable information is required as to the nature of the fatty matter originally used in its manufacture. For most textile purposes, however, full analyses are seldom required, and in general, a fairly accurate estimation of the value of a sample may be deduced from the results obtained in the determination of water, fatty acids, total alkali, and free alkali.

Determination of Water.—Weigh out in a porcelain basin from 3 to 5 grms. of the soap in thin shavings cut from the middle of a bar, and place the basin and contents in a steam oven for about three hours; then cool and weigh; the loss in weight indicates the water which has evaporated. The heating and weighing must be repeated until no further loss occurs. From the result obtained the percentage amount of water can be easily calculated.

Total Alkali.—The alkali present in soap may be of two kinds, viz. :—Combined alkali and free alkali. The former consists of that portion which is combined with the fatty acids, while the latter is free or uncombined, *i.e.*, it is in excess of the amount required to convert the whole of the oil or fat into a neutral soap. Hence total alkali includes combined alkali + free alkali.

Determination of Total Alkali.—About 3 to 5 grms. of the soap are dissolved in a small quantity of hot water contained in a beaker, and a few drops of a solution of methyl orange added. Normal sulphuric acid is then run into the liquid from a burette, until the yellow colour changes to pink. Each c.c. of the acid is equivalent to 0.031 grm. sodium oxide, (Na_2O) or 0.047 grm. potassium oxide K_2O.

If the soap is a soda soap, the result is expressed in terms of Na_2O, while the result for a potash soap is expressed as K_2O.

Example :—

Weight of soda soap taken = 3.3230 grms.

Volume of normal H_2SO_4 required = 9 c.cs.

Therefore the total Na_2O contained in 3.3230 grms. of the soap = 0.031 × 9 = 0.279 grm., and the per cent. amount = $\frac{100 \times 0.279}{3.3230} = 8.39$.

Uncombined or *Free Alkali.*—The soap which was dried in the experiment for the determination of moisture is dissolved in pure hot alcohol. If a whitish residue is noticed on the bottom of the beaker after dissolution has been effected, the alcoholic soap solution should be carefully decanted into another beaker.

and the residue rinsed once or twice with pure alcohol, the washings being added to the main solution. A few drops of alcoholic phenolphthalein solution are added and the liquid titrated with $\frac{N}{10}H_2SO_4$ until the pink colour disappears. Each c.c. of $\frac{N}{10}$ acid used, corresponds to .004 grm. NaOH, or, in the case of a potash soap, to .0056 grm. KOH. The white residue which remains in the first beaker may contain sodium carbonate—or K_2CO_3—which is insoluble in alcohol. Water is added, and the solution obtained titrated with $\frac{N}{10}$ acid, using a few drops of a solution of methyl orange as indicator. Each c.c. of acid corresponds to .0053 grm. Na_2CO_3, or to .0069 grm. K_2CO_3. If only a few drops of acid are required to change the colour of the indicator, it will be obvious that the amount of free alkali present in the sample is insignificant.

Fatty Acids.—There are several methods in use for the estimation of the fatty acids in a sample of soap, but perhaps the simplest and best known is the wax method, which is capable of yielding good results when carried out carefully. It cannot be used when the fatty matter is required for further examination.

About 5 to 8 grms. of the soap are dissolved in hot water contained in a beaker; a few drops of methyl orange solution are added and the liquid titrated with $\frac{N}{1}H_2SO_4$ until about 10 c.cs have been added over and above the volume required to change the colour of the indicator. The liquid is then heated, and about 8 grms. of paraffin wax (which must be accurately weighed) added to the contents of the beaker; the wax melts and mixes with the liquid fatty acids on the surface of the liquid in the beaker. It is advisable to heat the beaker and contents over a water bath for a short time, in order to facilitate the separation of all water from the melted layer of fat and wax. The mixture is then allowed to cool, when a firm cake of wax and fatty acids is obtained. Finally, the cake is carefully removed, rinsed with cold water, allowed to drain, dried with filter paper and weighed. From the weight obtained, the weight of wax is subtracted, the result indicating the amount of fatty acids in the sample of soap taken.

Interpretation of Analytical Results.—In order to arrive at the approximate value of a sample of soap from the results of analysis, certain well-known facts have to be taken into consideration. For example:—A well made soda soap contains from 60-66 per cent. fatty acids; it should be practically free from unsaponified fat, and should not contain more than a trace of free alkali. The fatty matter is sometimes returned as fatty acids, but more frequently as fatty anhydrides, in which form it is present in soap. In the former case, the figure will be higher than

the amount of fatty matter actually present, owing to the hydration which occurs when the soap is decomposed by acid. This will be clearly understood if we consider that (*a*), a fatty anhydride consists of two molecules of the corresponding fatty acid, from which, one molecule of water has been removed, thus :—

$$2C_{17}H_{35}.COOH = \begin{matrix}C_{17}H_{35}.CO\\C_{17}H_{35}.CO\end{matrix}\!\!>\!O + H_2O;$$

Stearic acid = stearic anhydride + water;

b), soap is formed by saturating the anhydride with sodium oxide (Na_2O), as :—

$$\begin{matrix}C_{17}H_{35}.CO\\C_{17}H_{35}.CO\end{matrix}\!\!>\!O + Na_2O = 2C_{17}H_{35}.COONa;$$

and (*c*), that the addition of acid to the soap during analysis, causes hydration to take place, the Na_2O being displaced by H_2O, and the free fat acids liberated, as represented by the following equation :—

$$\left(\begin{matrix}C_{17}H_{35}.CO\\C_{17}H_{35}.CO\end{matrix}\!\!>\!O + O\!<\!Na_2\right) + SO_4\!<\!H_2 = \left(\begin{matrix}C_{17}H_{35}.CO\\C_{17}H_{35}.CO\end{matrix}\!\!>\!O + H_2O\right) + Na_2SO_4.$$

Fatty anhydride + sodium oxide + sulphuric acid = Fatty anhydride + water + sodium sulphate.

Soap — Fatty acid

or $2C_{17}H_{35}.COONa + H_2SO_4 = 2C_{17}H_{35}.COOH + Na_2SO_4.$

Sodium stearate + sulphuric acid = stearic acid + sodium sulphate.

Hence, it is customary to return the fatty matter as anhydride (usually stearic anhydride), and the combined alkali as Na_2O. As 100 parts of stearic acid are equivalent to 97 parts of the anhydride, it is only necessary to multiply the weight of the fatty acid content, by the factor 0.97 in order to express the result as stearic anhydride. If unsaponified fat is present, it will be weighed along with the fatty acids. As a rule small quantities of free fat in laundry soaps are not objectionable for they are more or less readily neutralised, or emulsified, by the alkali used in the washing operations. The amount of combined alkali in a good quality soap, should not be lower than 7 per cent., while it may be as high as 9 per cent., according to the nature and amount of the fatty acids. 100 parts of stearic acid require 10.9 parts of Na_2O for neutralisation, so that the approximate theoretical amount which should be present in a soap, can be easily calculated from the fatty acid content, thus serving to check the actual figure obtained. It rarely happens, however, that the figure deduced theoretically agrees with the analytical figure, owing to the difference in the molecular weights of the fatty acids.

The lower the molecular weights of the latter, the higher will be the percentage of combined alkali.

The composition of a few typical good quality laundry soaps is given in the following table:—

Kind of Soap.	Fatty Anhydrides.	Combined Alkali.	Free Alkali (Carbonate).	Water, etc.
White Curd.....	60·25	7·38	0·18	32·19
Mottled ,, ...	64·14	8·52	0·45	26·89
Brown or "Black" ..	62·34	7·45	0·93	29·28
"Olive Oil"	61·24	7·12	0·20	31·44
Soft	40·12	8·80	0·90	50·18

Soap-Powders, Washing Powders, or **"Lessives."**—The majority of the proprietary washing powders on the market, consist of mixtures in various proportions of dried and finely powdered soap, and sodium carbonate. Other common constituents are silicate of soda, and borax, while a large number of powders of recent introduction contain variable quantities of sodium perborate. The latter mixtures act both as detergents and bleaching agents.

Generally speaking, washing powders offer no advantage over ordinary soap, or mixtures of soap and sodium carbonate in known proportions; they are more readily soluble, however, than ordinary soap.

It has been shown by several observers that silicate powders are more or less injurious, owing to the readiness with which insoluble silica is deposited in the fibres, while it is certainly more satisfactory to use sodium perborate alone, than when mixed with several other substances, some of which may be absolutely useless as detergents, or even act injuriously on the fibres. The value of unadulterated soap powders is dependent, of course, upon the nature of the soaps from which they have been made, and the amount of water present.

The composition of several washing powders is given in the following table:—

	Dry Soap.	Sodium Carbonate.	Silicate of Soda.
1	10·21	66·42	10·43
2	85·23	4·21	—
3	50·34	41·20	—
4	24·63	62·14	8·76
5	15·42	78·22	—
6	—	52·27	10·43
7	—	45·66	23·47

The table given below (*Technische Rundschau, 1909*), shows the variable nature of perborate washing powders:—

	Sodium Perborate + Water of Crystallisation.	Soap.	Sodium Carbonate.	Silicate of Soda.	Water.
1....	10·40	23·97	27·17	8·36	30·10
2....	10·20	38·80	22·59	2·72	25·69
3....	8·47	37·53	23.58	2·88	27·54
4....	9·82	20·85	36·24	3·50	29·59
5....	5·78	8·55	49·27	—	36·40
6....	11·04	14·43	34·80	4·65	34·18
7....	4·62	34·79	36·91	—	23·68
8....	3·08	17·74	51·15	2·34	25·69
9....	8·09	17·37	64·79	—	9·75

Benzine soaps are sometimes used in the laundry for the local treatment of stains containing grease. They differ from ordinary soaps in that they are practically anhydrous, and usually contain excess of free fatty acids. Their use depends upon the fact that they are more or less freely soluble in benzine, the solutions thus obtained, being less liable to take fire under working conditions, than when benzine is used alone, while the possession of properties which are characteristic of weak alkalies, facilitates their action on fatty matter, as well as on the dirt with which it is usually associated, when present in the form of stains on textile articles. A solution of benzine soap in benzine, exerts a powerful solvent action even on highly resistant forms of greasy matter, and when used for removing stains of this nature, it should be assisted in its action by mild friction, *e.g.*, brushing, in order to ensure the intimate contact of the liquid with as large a surface as possible of the matter to be removed.

Monopole Soap (*Bayer*).—This is an interesting compound prepared by heating sulphonated oils, *e.g.*, Turkey-red oil, with alkali, and boiling the mass until it gelatinises on cooling. It differs from ordinary soap in being unaffected in presence of various acids, and neutral salts. Thus, it is not precipitated when added to water of a high degree of hardness, but is actually capable of effecting the dissolution of the precipitated lime soaps, or "scum," which are deposited on the washing cylinders, in ordinary laundry practice. Owing to its strong capillary action, a solution of Monopole soap is able to wet out articles rapidly, and to penetrate into the interior of the fibres with great readiness, thus facilitating the removal of impurities, while it appears to exercise a brightening action even on the most sensitive colours.

Tetrapol.—This patent detergent has been introduced by the Bayer Co., Ltd. It possesses the characteristic properties of a

sulphonated oil compound, (*e.g.*, Monopole soap), as well as those of a non-inflammable, organic solvent of fats. Consequently, it is entirely free from the common defects associated with the use of ordinary soap, and from the danger of fire which accompanies the use of inflammable fat solvents.

Tetrapol has no injurious action on either vegetable or animal fibres, and the cost of washing is said to compare favourably with other detergents. Its use in conjunction with hard water obviates the formation of lime-soaps, and consequent incrustation of the washing cylinders. Other advantages are as follows:—It is neutral. Hence, it does not readily induce the shrinkage of woollen goods. It possesses the capacity of dissolving grease, etc., in a high degree. The most sensitive colours are unaffected by its use, and it may be employed with equal advantage in the cleansing of all classes of fibrous materials.

The washing power of Tetrapol has been compared with eight other detergents by Leimdörfer, who found that after washing various articles by hand for twenty times with Tetrapol, the loss in weight scarcely differed from that which occurred when a good curd soap was employed, while the resistance against tearing was considerably higher. Sensitive fabrics such as those made of silk, were found to retain their brilliance and elasticity.

Nature of Material.	Results of Tests after Hand-washing Twenty Times with :—			
	Tetrapol.		Seven other Detergents.	
	Percentage Losses.		Minimum and Maximum Losses.	
	Weight.	Strength.	Weight.	Strength.
Linen Fabrics:				
Coarse House Linen..	2·7	13·8	3·8 — 9·2	18·6 — 29·4
Good Medium Linen..	3·2	16·4	4·2 — 8·6	21·3 — 32·6
Finest Linen	3·6	17·1	4·9 —10·4	20·4 — 36·8
Cotton Fabrics:				
White	5·0	19·7	5·9 — 8·7	19·7 — 32·4
Red	4·3	16·2	7·0 — 9·4	23·0 — 30·6
Green	11·8	34·3	8·6 —18·5	26·2 — 52·8
Blue	4·2	14·6	4·2 —10·3	18·6 — 36·5
Woollen Fabrics:				
Undyed	2·9	16·7	4·2 — 8·6	21·8 — 28·6
Red	5·2	19·4	6·9 —10·2	25·6 — 38·6
Green	2·4	16·2	4·0 —16·2	24·0 — 35·6
Blue	2·1	15·1	3·5 — 8·6	13·6 — 32·3
Black	4·3	19·4	5·7 —21·5	23·4 — 36·3

The actual figures obtained for Tetrapol, taken from the *Seifensieder-Zeitung 1908, p. 579*, are tabulated above, and

brief comparison is made with the widely varying results obtained with seven other detergents.

When employing Tetrapol for the first time in machines, it is advantageous to first boil out the washing cylinders with a weak solution of the substance containing a little soda, in order to remove the lime soaps and associated dirt left by other detergents. This preliminary operation is of considerable importance, in view of the fact, that it prevents such impurities from being subsequently deposited on the goods, owing to the loosening action of Tetrapol. As the latter occurs in commerce in the liquid form, it only needs adding to *warm* water whilst stirring. Boiling up with steam when preparing the liquor should be carefully avoided.

Sodium Carbonate, Na_2CO_3.—This substance is used in the laundry under the names of washing soda, pure, refined, and 58 per cent. "alkali," "crystal-carbonate," sesqui-carbonate of soda, and soda ash.

Washing soda or soda crystals is represented by the chemical formula $Na_2CO_3.10H_2O$; it thus contains, when pure, almost 63 per cent. of water of crystallisation, which is useless, of course, for scouring purposes.

"*Crystal carbonate*," $Na_2CO_3.H_2O$, is a pure variety of sodium carbonate in the form of fine crystals. It contains about 14.5 per cent. of water.

Sesqui-carbonate of soda, $Na_2CO_3.2NaHCO_3.2H_2O$, is prepared by rapidly crystallising a solution of sodium bicarbonate, which has been caused to part with a certain amount of carbon-dioxide by the action of heat. It may also be obtained by mixing solutions of sodium carbonate, and the bicarbonate.

Soda ash, Na_2CO_3, is a crude anhydrous sodium-carbonate, and is liable to contain a considerable amount of impurities.

Pure, refined, and *58 per cent. "alkali,"* are commercial terms given to an almost pure anhydrous form of sodium carbonate. These brands are used in enormous quantities for the cleansing of vegetable fibres, and constitute the chief varieties used in laundry work.

Sodium carbonate is manufactured by two distinct processes, one of which is known as the *ammonia* or *Solvay* process, and the other as the *Leblanc* process. In the former process, brine is first saturated with ammonia gas and the resultant liquor carbonated by means of a stream of carbon dioxide gas, and subsequently concentrated, whereby sodium bicarbonate is precipitated in the form of fine crystals. On ignition, the

latter yield anhydrous sodium carbonate. The following equations represent the principal reactions :—

(1). $NaCl+NH_3+CO_2+H_2O=NaHCO_3+NH_4Cl.$

(2). $2NaHCO_3=Na_2CO_3+H_2O+CO_2.$

For the successful working of the process, specially designed apparatus is requisite not merely for the completion of the changes given above, but also for the economical recovery and re-utilisation of the ammonia contained in the mother liquor.

The *Leblanc* process is more complicated. It consists of a series of operations which may be briefly described as follows :—

1. Common salt is first heated with sulphuric acid in a special retort. The chemical change which occurs is indicated by the following equation :—

(*a*). $NaCl+H_2SO_4=NaHSO_4+HCl.$

The residue in the retort is then heated to a higher temperature, the action being as follows :—

(*b*). $NaHSO_4+NaCl=Na_2SO_4+HCl.$

In these operations a large quantity of hydrochloric acid gas is evolved. This is led into condensing towers where it dissolves in water, the solution constituting the spirits of salt or muriatic acid of commerce. The solid product of the above reactions is termed salt cake.

2. The salt cake is next thoroughly mixed with powdered coal and limestone, and strongly heated in a reverberatory furnace. During this stage of manufacture, which is termed the "black ash" process, two important reactions take place, viz. :— The sodium sulphate is reduced to sulphide—

$$Na_2SO_4+2C=2CO_2+Na_2S;$$

and as the temperature increases, the latter reacts with the limestone, the chief products being sodium carbonate and calcium sulphide—

$$Na_2S+CaCO_3=Na_2CO_3+CaS.$$

3. In the third stage of the process, the "black ash" is allowed to cool, and then treated with water in large tanks. The sodium carbonate dissolves, and the solution is decanted from the insoluble calcium sulphide and subjected to various treatments according to the form of carbonate required. If it is allowed to stand, soda crystals, ($Na_2CO_3.10H_2O$), are ultimately deposited. If, on the other hand, it is evaporated, and the residue ignited, an impure form of sodium carbonate (soda ash), is obtained, while re-carbonation of the liquor converts many impurities into the carbonate, and precipitates others, so that purer products are obtained on evaporation. Thus, by concentrating the carbonated liquor in an iron pan provided with mechanical agitators, a black salt ultimately separates out, and this on ignition yields a good

quality of soda ash. The latter is converted into "refined alkali" by first dissolving it in water and adding a little bleaching powder solution in order to precipitate traces of iron; the purified solution is then concentrated, allowed to crystallise, and the crystals finally ignited. The strength of commercial sodium carbonate is generally expressed in degrees which correspond to the percentage of sodium oxide, Na_2O, plus one. Thus the chief varieties vary in strength from 48°-58°.

Properties.—Anhydrous sodium carbonate does not dissolve very readily in cold water, owing to the formation of hard lumps at the moment it comes into contact with the water. Hot water, however, speedily effects its dissolution.

It is customary in most laundries to make a standard solution for general use, *i.e.*, a solution containing a definite weight in one gallon. The solution is made in a galvanized iron tank provided with an open steam pipe, and varies in strength from about 2½ to 5 per cent., *i.e.*, 2½ lbs.-5 lbs. in 10 gallons.

Sodium carbonate readily undergoes hydrolysis in presence of water. Its solution turns red litmus blue, and neutralises acids with the evolution of carbon dioxide and formation of well defined salts. Owing to its alkaline nature it exercises a powerful emulsifying action on vegetable and animal oils and fats. Anhydrous sodium carbonate is commonly termed "alkali" presumably on account of the fact that it possesses similar properties to the soluble portion of the ashes of plants, *i.e.*, the *alkali* of the Arabians.

Valuation of Sodium Carbonate.—Sodium carbonate intended for use in laundries should be free from iron and caustic soda, as well as from impurities of a non-detergent character. The former is apt to give rise to yellow stains, while caustic soda may affect certain classes of goods injuriously. As already mentioned, the brands of sodium carbonate known as pure, 58 per cent., and refined alkali, consist essentially of pure Na_2CO_3, and, as the composition of these substances is generally kept up to a definite standard by the alkali makers' chemists, it is seldom necessary to apply any elaborate tests in the laundry. Some brands of sodium carbonate—especially those sold under the name of soda ash—usually contain variable quantities of caustic soda, which may be detected, and the approximate amount estimated by the methods given below:—

Detection and Estimation of Caustic Soda.—A small quantity (one or two grams), of the dried sample to be tested, is thoroughly agitated for some time in about 25 c.cs. of strong alcohol. The insoluble carbonate is allowed to settle and a portion of the clear liquid decanted into a beaker; a few drops of

phenol phthalein solution are then added, the production of a pink colouration indicating the presence of caustic soda. The approximate amount of the latter can be determined by making up the solution to a definite volume in the first instance, and allowing to settle. Ten to 25 c.cs. of the clear solution are then withdrawn by means of a pipette, introduced into a basin, a little phenol phthalein solution added, and deci-normal sulphuric acid run in from a burette until the pink colour disappears. Each c.c. of $\frac{N}{10}H_2SO_4$=0.004 grm. NaOH.

Total alkali is estimated by titrating an aqueous solution containing a known weight of the sample with normal sulphuric acid, using methyl orange solution as indicator. Each c.c. of $\frac{N}{1}$ H_2SO_4=0.031 grm. Na_2O, or expressed as carbonate, 0.053 grm. The approximate strength of a solution of sodium carbonate is frequently determined with the aid of Twaddell's hydrometer, and subsequent reference to a table of percentages—

PERCENTAGES OF SODIUM CARBONATE IN SODIUM CARBONATE SOLUTIONS OF KNOWN SPECIFIC GRAVITY AT 15°C.

Degrees on Twaddell's Hydrometer.	Percentage by Weight.		
	Na_2CO_3.	$Na_2CO_3.10H_2O$.	Na_2O.
1	0·47	1·27	0·28
2	0·95	2.56	0·56
3	1·42	3·82	0·84
4	1·90	5·13	1·11
5	2·38	6·99	1·39
6	2·85	7·69	1·67
7	3·33	8·98	1·95
8	3·80	10·25	2·22
9	4·28	11 55	2·50
10	4·76	12·80	2·78
11	5·23	14·11	3·06
12	6·71	15·41	3·34
13	6·17	16·65	3·61
14	6·64	17·92	3·88
15	7·10	19·16	4·16
16	7·57	20·42	4·42
17	8·04	21·69	4·70
18	8·51	22·94	4·97
19	8·97	24·20	5·24
20	9·43	25·44	5·52
21	9·90	26·71	5·79
22	10·37	27·98	6·06
23	10·83	29·22	6·33
24	11·30	30·49	6·61
25	11·76	31·90	6·88
26	12·23	33·00	7·15
27	12·70	34·27	7·42
28	13·16	35·45	7·70
29	13·63	36·78	7·97
30	14·09	38·02	8·24

Detection of Iron.—Iron is rarely present in the best brands of commercial sodium carbonate, but if it is suspected, a few grms. of the sample are dissolved in a little water, and pure dilute hydrochloric acid added to the solution until effervescence ceases. A few drops of concentrated nitric acid are then added, and the liquid heated. Finally, it is allowed to cool and tested with a solution of yellow prussiate of potash, when the production of a blue or green colour indicates the presence of iron.

Sodium hydrate or **caustic soda**, NaOH or Na_2O+H_2O, occurs in commerce in the form of fused greyish white blocks, in powder form, in sticks, and in solution. It possesses extremely powerful detergent properties, but finds little use in British and Irish laundry practice, except in a few cases where unbleached linen and cotton articles have to be scoured and whitened.

Caustic soda is manufactured by several processes, but the oldest method, as well as the simplest, consists in treating a hot solution of sodium carbonate with slaked lime—

$$Na_2CO_3+Ca(OH)_2=2NaOH+CaCO_3.$$

The liquor is not allowed to become concentrated, as the reverse reaction increases with the strength of the solution—

$$2NaOH+CaCO_3=Na_2CO_3+Ca(OH)_2.$$

The weak caustic liquor is drawn off from the precipitated calcium carbonate and concentrated in iron pans, a little nitre being added during the final stages, in order to effect the conversion of traces of sodium sulphate, and other impurities, into the hydrate.

Properties, Uses, and Valuation.—Caustic soda is a white, hard, and highly deliquescent substance. It dissolves readily in cold water with the production of a considerable amount of heat, and both the solid and solution readily absorb carbon dioxide from the air. The aqueous solution is strongly alkaline, possesses a soapy feel, and exerts a powerful caustic action on the skin.

Enormous quantities of caustic soda are used in the manufacture of hard soaps, and in the bleaching of cotton and linen goods, while it is also employed on a somewhat extensive scale in American laundry practice. The strength of commercial brands of caustic soda, is expressed in the same way as in the case of the carbonate, *i.e.*, in degrees, which are equivalent to the percentage of Na_2O (sodium oxide), plus one. Thus, the chief brands have 60, 70, and 77 degrees of strength.

It is usually valued in the laboratory by determining the total alkali content, *i.e.*, Na_2O, using normal acid with methyl orange as indicator, 1 c.c. $\frac{N}{1}$-H_2SO_4 = .031 grm. Na_2O, or 0.04 grm. NaOH.

Sodium carbonate, silicate, and aluminate, are frequently found in commercial varieties of caustic soda, and are, of course, returned as Na_2O in the above estimation. As a general rule, however, they are present in such small quantities as to render their estimation unnecessary.

Potassium Carbonate, K_2CO_3, *Potash* or *Pearlash.*—Potassium carbonate was formerly prepared by extracting the ashes of land plants with water, filtering, and evaporating the solution to dryness. The residue thus obtained was known to the Arabians as *kali*, which corresponds to the term *potash*. It is now chiefly manufactured by the Leblanc process—as used in the manufacture of sodium carbonate—from the potassium chloride deposits occurring in the Stassfurt and other districts.

Potassium carbonate is a white, highly deliquescent substance; it crystallises with $1\frac{1}{2}$ molecules of water of crystallisation. In contact with water, it readily undergoes dissociation, yielding an alkaline solution which possesses strong detergent properties.

Potassium carbonate is frequently used under the name of pearlash, for cleaning certain varieties of raw wool, but seldom finds employment in the laundry industry. It is more expensive than the corresponding sodium salt and exhibits a tendency to liquefy on keeping. Its chief use is in connection with the manufacture of soft soaps and special varieties of glass.

Potassium hydrate or **caustic potash** possesses somewhat similar properties to caustic soda and may be prepared in the same way, using potassium carbonate instead of sodium carbonate. It is rarely used by the launderer as a detergent, but finds extensive employment in the manufacture of soft soaps. In many of its reactions, *e.g.*, in the saponification of oils and fats, it appears to be more chemically active than the corresponding sodium compound.

Sodium Silicate or "**Soluble Glass,**" $Na_2Si_2O_5$.—This substance is manufactured by fusing sand or silica (SiO_2) with sodium carbonate. It is sent into the market in the form of a thick viscous liquid, or as a greenish coloured vitreous mass. The former readily mixes with hot water, but the latter only dissolves slowly, yielding a viscous solution. In the powdered form, sodium silicate is used to a considerable extent in the preparation of "washing powders" or "lessives," which are largely employed in laundries on the continent, and to a moderate extent in Great Britain and Ireland. The majority of silicate washing powders consist of varying proportions of sodium carbonate and sodium silicate, with or without the addition of an adulterant such as common salt, etc. Many preparations also contain powdered

soap, while those of recent introduction frequently contain sodium perborate as well.

Sodium silicate is rarely used alone for cleansing purposes in the laundry, but it has long been employed by the calico-printer for "clearing" certain kinds of printed cotton goods. Its detergent properties depend principally upon its property of undergoing hydrolysis in aqueous solution, this being more or less complete according to the strength and temperature of the solution. The weaker the solution and the higher its temperature, the more complete is the hydrolysis; hence, it is conceivable that the weak solutions of silicate washing powders used in the laundry contain the silicate of soda in an almost complete state of hydrolysis, *i.e.*, in the form of caustic soda and colloidal silicic acid.

Borax, $Na_2B_4O_7.10H_2O$.—This substance is sent into the market in the form of prismatic crystals containing ten molecules of water of crystallisation, and in the form of an anhydrous powder. It is prepared in large quantities from boric acid, which is found in the volcanic districts of Tuscany. The crude acid is mixed with sodium carbonate, and the mixture heated in a furnace, whereby carbon dioxide is evolved; the residue—which consists chiefly of borax—is then agitated with water, and the solution of borax freed from suspended impurities by filtration. Finally, the solution is allowed to crystallise.

The chemical changes which occur in the above operation may be represented by the following equation:—

$$4H_3BO_3 + Na_2CO_3 = Na_2B_4O_7 + CO_2 + 6H_2O.$$

Boric acid + sodium carbonate = borax + carbon dioxide + water.

Borax dissolves in 20 times its weight of cold and half its weight of hot water, yielding a solution which possesses a mild alkaline reaction and a sweetish taste. It enters largely into the composition of many powdered "glazes," and is sometimes used as a mild detergent, and for softening water. Borax should only be used sparingly in finishing processes, as the presence of excessive amounts of metallic salts in finishing pastes, tends to produce considerable friction between the heated rollers, or irons, and the materials being finished, with the inevitable result, that collars, cuffs, etc., are gradually rendered harsh, and the fibres very much weakened.

Ammonium Hydroxide, NH_4OH, *Ammonia*, or *Liquor Ammonia*.—This compound is frequently employed as a mild scouring agent in the treatment of woollens; it is also very useful in the laundry for the removal of certain stains, and for other minor purposes. The ammonia liquor of commerce is a solution

of ammonia gas in water, the greatest bulk of it being obtained either directly or indirectly from the gas liquor of the gas works. Ammonia gas is represented by the chemical formula NH_3; it is extremely soluble in water, great heat and increase in volume being produced during dissolution. The solution obtained, *i.e.*, the ordinary ammonia liquor of commerce, is regarded as a hydrate of the radicle NH_4, formed according to the following equation :—$NH_3 + H_2O = NH_4OH$.

The strongest liquor ammonia has a specific gravity of 0.880, and contains about 35 per cent. of ammonia gas; it possesses strong alkaline properties, and forms a series of well defined ammonium salts when neutralised with acids.

Ammonia saponifies various vegetable and animal oils and fats more or less completely, with the production of ammonia-soaps; these are used to a considerable extent in the finishing of textile fabrics.

The approximate value of a sample of ammonia liquor, may be determined with the aid of Twaddell's hydrometer—for liquids lighter than water—and subsequent reference to a table of specific gravities and strengths. The liquor is usually sent out in glass stoppered 'Winchester' bottles, carboys, or in wrought iron drums, which should always be kept tightly stoppered to prevent the escape of gas. Metallic copper is readily acted upon by ammonia, forming a compound which may give rise to stains if brought into contact with textile materials; hence, operations involving the use of a considerable amount of ammonia, should not be carried on in copper vessels.

Soap-Bark or **Quillaia Bark.**—This substance constitutes the bark of an evergreen tree known to botanists as *Quillaia saponaria*, which grows in South America. The commercial bark is of a yellowish white colour; it is heavier than water, and contains a large amount of mineral matter.

On digesting the bark with hot water, a liquid is obtained which possesses very great lathering properties. Indeed, it is doubtful whether any other substance yields a lather so readily. Soap-bark infusions possess considerable cleansing power, and appear to exercise an emulsifying action on greasy matter. They have been used for many years in the process of cleansing dyed woollen and worsted goods, as well as in laundry processes. The active ingredient in the bark is known as saponin, and can be extracted with boiling alcohol. It possesses strong reducing properties.

Malt and Malt Extract.—Malt preparations are not usually regarded as detergents, inasmuch as their use is primarily dependent upon the fact, that under suitable conditions they possess

the power of effecting the conversion of starch into soluble derivatives. As such preparations, however, are now extensively employed in the cleansing operations carried on in the laundry, we may conveniently include an account of them in this section.

Malt.—This is the name given to the grain of barley which has been allowed to germinate partially. Germination is induced by first steeping the grain in water for a few days, when it swells, becomes tender, and imparts a reddish colour to the water. It is then separated from the latter, and spread in a thick layer, (about 1-2 feet), on a stone floor. In a short time, germination begins, and is accompanied by the development of heat. At this stage, the grain is spread more thinly, and turned over from time to time during about two days, so that germination takes place slowly. The partially germinated grain is then made into heaps, and allowed to stand for several hours, during which time its temperature gradually rises until it reaches a point high enough to arrest germination. Finally it is carefully dried in a kiln at a medium temperature.

The product so obtained varies in colour according to the length of time occupied in treatment and the temperature which obtains in drying. Usually, commercial malt is of a pale amber, or brown colour. When treated with water, about 70 per cent. dissolves, the soluble constituents consisting chiefly of maltose, dextrin, albumin, and phosphates.

Malt differs from the parent substance barley, in that the starch naturally present in the latter has been more or less completely converted into maltose and dextrin. This alteration of the starch is brought about by peculiar ferments or *enzymes* originally present in the grain. These appear to undergo considerable development during the malting process, inasmuch as malted barley is capable of readily effecting the conversion of ordinary gelatinised starch into soluble derivatives, while the untreated grain possesses little action in this respect.

Formerly, it was customary to recognise only one ferment in malt, this being known as *diastase*, but recent work shows that many other enzymes are developed during the malting process, in addition to those which exert such a powerful action on starch. Hence, the term "diastase" is now understood to mean all the enzymes of malt, while the names of specific enzymes are derived from the materials acted upon, the termination—ase being added in each case. Thus, the enzyme which is capable of effecting the conversion of amylaceous matter, *i.e.*, starch, is termed "amylase," while according to Holderer (*Jour. Soc. Chem. Industry*, 1909, p. 733), barley and malt contain the enzymes *glutenase*, *trehalase*, *cellase*, and *sucrase*, in addition to *amylase* and several others.

Amylase appears to possess two functions, in that gelatinised starch is first liquefied by its action, the product apparently possessing properties similar to those of soluble starch. In the second place, the further action of amylase results in the conversion of the liquefied starch into maltose and dextrin. The first stage in the conversion of starch by malt is therefore said to be due to the liquefying power of amylase, while the final stage is due to its saccharifying power, *i.e.*, its power of converting amylaceous matter into sugars.

All enzymes are believed to be of an albuminoid nature, and very small amounts are capable of altering relatively large quantities of the substances on which they act. The principal chemical changes brought about by the action of the best known enzymes are due to hydrolysis, although in some cases oxidation and decomposition are induced. A chemical change induced by enzymatic action may be more or less complete according to (*a*), the nature of the enzymes; (*b*) the physical condition, nature, and amount of the substance acted on, and (*c*), the temperature at which the action takes place. Thus, it has been already mentioned, that when the enzymes of malt act on gelatinised starch under suitable conditions, the first conversion product is a soluble starch of a liquid nature. This may be regarded as the simplest product of the gradual conversion of starch by means of hydrolytic ferments.

A similar change takes place when starch is treated with weak acids under suitable conditions. It is noteworthy, however, that ungelatinised starch is only slowly acted on by amylase, whereas the use of starch of the same physical condition, in the acid-hydrolysis process, does not appear to exert a pronounced retarding influence on the hydrolytic action of the acid.

The exercise of the second function of amylase on liquefied starch brings about its conversion into sugar, (maltose), and dextrin, or as usually stated, saccharification takes place. This change may be represented by the following equation :—

$$3C_6H_{10}O_5 + H_2O = C_{12}H_{22}O_{11} + C_6H_{10}O_5.$$
Starch + water = maltose + dextrin.

Maltose and dextrin may be termed the intermediate products of the hydrolytic conversion of starch, while if the action of amylase is allowed to continue for a sufficient length of time, the dextrin is completely converted into maltose, which is generally considered to be the final product of the action of malt enzymes on starch.

An analogous series of changes takes place in the acid hydrolysis of starch, but in this case, the sugar corresponding to maltose undergoes further hydrolysis, the final product being glucose, as :—

$$C_{12}H_{22}O_{11} + H_2O = 2C_6H_{12}O_6$$

It would appear from the foregoing remarks, that the liquefaction or conversion of starch into soluble starch must precede its saccharification, but it is evident that so soon as a certain amount of liquefaction has been effected, saccharification begins; hence, the two functions of amylase are undoubtedly exercised concurrently. The terms "liquefying enzymes" and "saccharifying enzymes" are now used to indicate two distinct amylolytic enzymes, which act on starch as their names imply. They correspond, of course, with the two functions of amylase mentioned above, and according to Pollak, (*Jour. Soc. Chem. Industry*, 1903, p. 1,370), there exists no relationship between their respective properties.

It is well known that the activity of an enzyme is largely governed by the temperature of the medium in which it is contained; activity is slow at low temperatures, but increases gradually as the temperature rises, until a maximum is reached. Further increase of temperature above this point reduces the activity, until finally, the enzymes appear to be more or less completely altered, and with few exceptions are incapable of being regenerated on cooling. Activity also ceases in presence of alkalies or moderately strong acids. According to May, (*Jour. Soc. Dyers and Colourists*, 1911, p. 88), the liquefying enzymes of malt in an aqueous solution have an optimum temperature of 145° F., their action not being completely destroyed until a temperature of 212° F. is reached. On the other hand, the saccharifying enzymes have an optimum temperature of 120° F., and cease to act at 150° F.

Malt Extract.—Extract of malt is prepared by macerating coarsely powdered malt with its own weight of water for several hours, then adding 3-4 times the original volume of water at 35° C., and digesting for an hour at a temperature not exceeding 55° C. Finally, the solution is filtered and subsequently evaporated to a syrupy consistency under diminished pressure.

The product is a pale amber, or brown, viscous liquid, possessing an agreeable odour, and a sweet taste. It contains a high proportion of the natural enzymes of malted barley, and is soluble in all proportions in water.

A considerable number of proprietary malt extract preparations, specially manufactured for use in the textile industry, are on the market. Amongst these may be mentioned "Brax Diastase Extract," "Malt Extract," "Brimal," "Diastofor," etc.

Malt preparations should be kept in well-closed vessels in a cool place, as they exhibit a tendency to undergo spontaneous fermentation on keeping, especially when exposed to air. The lower the viscosity, the more readily is fermentation induced.

Uses and Valuation.—Malt preparations are used in the laundry chiefly for the purpose of facilitating the removal of old starch from heavily finished articles in the breakdown. In this connection they are invaluable, especially when the goods to be treated contain colour effects, or in fact in all cases where the cleansing of starched articles must be accompanied with a minimum amount of friction. They also find a limited use in the preparation of certain kinds of laundry finishing pastes. It is inadvisable to employ them at a higher temperature than about 120° F., in presence of textiles, since there is considerable danger of some of the albuminous matter being coagulated, and precipitated on the fibres in conjunction with colouring matter. Their action is most powerful, however, at temperatures between 140° to 150° F. Owing to the ease with which malt extracts may be sophisticated, it is of great importance that valuation tests be applied from time to time. Unfortunately, no simple and entirely satisfactory method of readily estimating the value of a sample is available, so that recourse must be had to more elaborate methods.

Malt preparations are frequently sold according to their diastatic (saccharifying) power, which is usually expressed in Lintner degrees. This scale was introduced by Lintner so long ago as 1886, and is based on the amount of malt extract required to produce sufficient maltose, in presence of starch, to decolourise 5 c.cs. of Fehling's solution.

It is evident, however, from a consideration of the properties of malt and its preparations, that the Lintner degree alone, does not represent the true value of a sample, since it conveys no information concerning the liquefactive power, a property which modern research has shown to be of the highest importance in connection with the rapid conversion of starch into soluble derivatives.

Several methods of a more or less complex nature have been introduced during the last few years for the determination of liquefactive power, and one of these is described below. In addition to such determinations, useful information is obtained by finding the specific gravity, and determining the percentage of reducing sugars. From the former result, the amount of total solids may be calculated, while in a complete analysis, the determination of the nitrogenous or protein content serves to check the figures obtained for diastatic and liquefying powers, inasmuch as it is well known that a preparation with a low protein content possesses low diastatic and presumably liquefactive powers. On the other hand, however, a high protein content cannot be regarded as an advantage, as it may indicate the presence of excess of colouring matter and coagulable albumin.

Harrison and Gair, (*Jour. Soc. Chem. Industry*, 1906, p. 830), proceed as follows in the determination of total solids and maltose.

Total Solids.—Twenty grms. are dissolved in water and made up to 100 c.cs., and the sp. gr. of the solution determined in the usual manner. The percentage of total solids is then calculated by the aid of the formula :—

$$T.S. = \frac{\text{Sp. gr.} - 1000}{3.92} \times 5.$$

Maltose.—Five c.cs. of the above 20 per cent. solution are diluted to 100 c.cs. Ten c.cs. of Fehling's solution are placed in a suitable vessel, and the malt extract solution run in from a burette until the blue colour is just discharged. The percentage of maltose is found with the aid of the formula $\frac{80.5}{m}$, where m = the number of c.cs. of malt extract used in effecting the decolourisation of 10 c.cs. of Fehling's solution.

Diastatic Power.—The diastatic power of malt extract may be estimated according to Lintner's method, or by means of a modification of this due to Ling. Harrison and Gair's method is also to be recommended when great accuracy is required. The first-named may be carried out as follows :—Two grms. of soluble starch (prepared according to the directions given below), are dissolved in about 60 c.cs. of warm water; the solution is then cooled and made up to 100 c.cs. with distilled water. Ten c.cs. of this solution are introduced into each of ten test tubes, and to the contents of each tube, a certain quantity of a 5 per cent. solution of the malt extract to be examined is added, *e.g.*, 0.1 c.c. is added to the 10 c.cs. of starch in the first test tube, 0.2 c.c. to the contents of the second, 0.3 c.c. to the third, and so on, 1 c.c. being added to the contents of the tenth test tube. The tubes and contents are allowed to stand for one hour at a uniform temperature of 70° F., (by placing in water maintained at that temperature), and then 5 c.cs. of Fehling's solution introduced into each. All the tubes are next placed in boiling water, and allowed to remain for ten minutes, after which the contents are carefully examined.

If the amount of maltose produced in any tube, is just sufficient to decolourise the 5 c.cs. of Fehling's solution added, no further examination is necessary. If, however, there is no test tube in which the contents exhibit an exact agreement between the amount of maltose formed and the decolourisation of 5 c.cs. of Fehling's solution, it will be necessary to choose a tube, the contents of which retain a faint trace of blue, while the contents of the adjacent tube, *i.e.*, the tube originally containing a greater amount of malt extract, should exhibit a yellowish hue, thus show-

ing that more maltose has been produced than is required to reduce 5 c.cs. of Fehling's solution. In this case, a little more malt extract may be added (not more than 1-50th c.c. at a time) to the contents of the tube chosen, until the blue colour is exactly discharged on allowing to stand as before. It is preferable, however, to take the mean of the amounts of malt extract originally added to the contents of the tube still retaining a blue colour, and to the contents of its neighbour respectively. Thus, if 0.7 c.c. of malt extract is too much, and 0.6 c.c. too little, the mean is taken as 0.65. From the result so obtained, the degree Lintner is calculated. 100° Lintner is regarded as the diastatic power of a malt extract when 0.1 c.c. of a 5 per cent. solution produces sufficient maltose under the conditions mentioned, to reduce exactly 5 c.cs. of Fehling's solution.

Suppose 0.2 c.c. is required; then the diastatic power is $\frac{100}{2}$ = 50, and so on. If the malt extract solution is too strong, a 1 per cent. solution should be employed and the figure obtained multiplied by 5, while in the case of a 10 per cent. solution being employed, the result should be divided by 2.

The soluble starch, and Fehling's solution required in the above experiment are prepared as follows:—

Preparation of Soluble Starch.—Purified potato starch is covered with hydrochloric acid of 7.5 per cent. strength, and the mixture allowed to stand for seven days at the ordinary temperature, or three days at 104° F. At the expiration of this time, the starch is found to have lost its property of yielding a paste, and gives a clear solution with warm water. It is freed from acid by repeatedly washing with cold water by decantation, until it exhibits a neutral reaction towards litmus paper. Finally, it is collected and dried carefully in the air.

Preparation of Fehling's Solution.—A. Dissolve 34.64 grms. of pure crystallised copper sulphate in sufficient water and finally make up to 500 c.cs.

B. 70 grms. of caustic soda and 480 grms. of recrystallised Rochelle salt, (sodium-potassium-tartrate), are dissolved in water and the solution made up to 500 c.cs.

Fehling's solution is prepared by carefully adding solution A, to an equal volume of solution B. It is best prepared as required, although it keeps fairly well when protected from light and air. Its condition may be ascertained by diluting with an equal volume of water and boiling for a few minutes. If in good condition, no trace of turbidity will be produced.

10 c.cs. of Fehling's solution are reduced by 0.0805 grm. of maltose, or 0.05 grm. glucose.

Harrison and Gair's method of determining the diastatic power of malt extract (*British Pharmaceutical Codex*, 1910), is carried out as given below:—1 grm. of anhydrous potato starch is mixed with a few c.cs. of cold distilled water in a mortar, and the mixture added to 65 c.cs. of boiling water, the mortar being rinsed out with sufficient water to make up the mucilage to 80 c.cs. It is then boiled for about a minute to ensure complete gelatinisation, and afterwards cooled to 46° C. At this stage, 0.2 grm. of the malt extract to be examined, dissolved in sufficient distilled water to measure 20 c.cs., is added, and the temperature of the mixture maintained at 40° C. for half an hour. It is next boiled to stop diastatic action, cooled, and made up to 100 c.cs. by the addition of distilled water. The amount of the solution thus prepared, which is required to reduce 10 c.cs. of Fehling's solution, (previously diluted with 40 c.cs. of water and boiled in a porcelain beaker), is then ascertained in the usual way. The amount of maltose introduced with the malt extract is deducted from the amount found, the former being determined by titrating 10 c.cs. of the diluted Fehling's solution with a solution containing 1 grm. of the malt extract in 100 c.cs.

In this method, diastatic power is expressed as the weight of starch converted by 100 parts of malt extract. The calculations are simplified by the use of the following formula, in which n = number of c.cs. used in the diastase titration, m = number of c.cs. of 1 per cent. solution of malt extract used in the maltose titration, and 1.184 is the factor $(\frac{100}{84.4})$, for calculating maltose into starch. Weight of anhydrous starch completely converted $= 1.184(\frac{8.05}{n} - \frac{1.61}{m})$, or diastatic power $= 592\ (\frac{8.05}{n} - \frac{1.61}{m})$.

If the result so obtained is over 250, a fresh experiment should be made using only half the above quantity of malt extract; the formula will then be:—

$$\text{D.P.} = 2 \times 592\ (\frac{8.05}{n} - \frac{1.61}{2m}).$$

If the result obtained is over 500, a further test should be made in which only one-fourth of the original quantity of malt extract is employed; then, diastatic power $= 4 \times 592\ (\frac{8.05}{n} - \frac{1.61}{4m})$. If necessary, the quantity of malt extract may be still further reduced, so that in the test which is taken as fixing the diastatic power of the extract, not more than half the starch is converted. This gives figures which are more properly comparable than is the case if the conversion is allowed to proceed further.

Liquefactive Power.—If the starch liquefying and saccharifying powers of malt enzymes have little or no relationship as is now generally believed, it is evident that a malt extract may have a low diastatic power, and yet possess a high liquefying power. On

the other hand, it is unlikely that a malt extract will possess a high diastatic power and a low liquefactive power, assuming, of course, that liquefaction precedes saccharification in the conversion process.

For many textile purposes a high liquefactive power may compensate for a low diastatic power, hence an accurate method of determining the former is highly desirable. Among the few methods which have been published, that due to Pollak, (*Jour. Soc. Chem. Industry*, 1903, p. 1,370), appears to be the simplest. It is carried out as follows :—A 3 per cent. paste made from purified anhydrous arrowroot starch is prepared, and 10 c.cs. measured into each of a series of test tubes, correction having been made for the quantity of paste which adheres to the sides of the pipette under standard conditions. The test tubes are then heated on a water-bath at 40° C., and the malt extract, in the form of a 0.2 per cent. solution, added to each of the tubes in increasing quantities. Each tube is thoroughly shaken, and the whole series is heated at a temperature of 37.6° C. on the water-bath for 30 minutes. The contents of each tube are then treated with a certain number of drops of strong caustic potash solution. In those tubes in which unliquefied starch is still present, the drops of alkali will fall to the bottom, retaining their rounded form; but in those tubes in which the starch is fully liquefied, the drops of alkali will be dispersed in their fall. A still sharper test is obtained by adding a drop of phenolphthalein solution to each tube and slowly inverting it once and then back again whilst closed with the finger. In presence of starch paste the red colouration is developed in uneven patches, whereas if the starch be fully liquefied the colouration takes place uniformly at once. In order to determine the amount of diastatic solution which should form the mean of the series chosen, a preliminary experiment should be made by causing one part of the malt extract in the form of a 2 per cent. solution, to act upon 7.5 times its weight of starch in the form of a 3 per cent. paste at 37.6° C., until a thermometer placed in the flask becomes distinctly visible; the time required for this reaction to take place is then noted. On the assumption that the quantity of starch liquefied is roughly proportional to the time required, the volume of 0.2 per cent. malt extract solution which will liquefy 10 c.cs. of 3 per cent. starch paste in 30 minutes can be calculated, and used for the middle member of the series of test-tubes, the other tubes receiving more and less respectively. The liquefying power is defined as the number of parts of starch which are fully liquefied by one part of the diastatic material in 30 minutes at 37.6° C.

Determination of Protein Content.—Introduce from 0.7-3.5 grms. (according to amount of protein matter), of the malt extract to be examined into a round Jena flask of from 250-500 c.cs. capacity; then add 10 grms. of powdered potassium sulphate, and from 15-25 c.cs. of concentrated pure sulphuric acid. Warm the flask gently over a gas flame, and when the first vigorous action has subsided, heat gradually until the liquid boils and frothing ceases. Continue the digestion until the liquid is practically colourless, at which stage, it is cooled, diluted with water and washed out into a Kjeldahl distilling flask of Jena glass, which is provided with a connection for attachment to a suitable condenser, and also with a tap-funnel containing a solution of caustic soda (about 30 grms. in 60 c.cs. of water). Small pieces of granulated zinc are placed in the flask to prevent bumping, and the apparatus fitted together and clamped in position. The caustic soda solution is then run in slowly and the liquid boiled vigorously until a drop of the distillate ceases to turn red litmus paper blue. The end of the condenser communicates with a receiver containing about 25 c.cs. of $\frac{N}{2}$ H_2SO_4, and should be so arranged that it dips just beneath the surface of the acid.

In this process the protein matter is oxidised, the nitrogen being converted into ammonium sulphate. The latter is then distilled with excess of caustic soda, and the ammonia gas evolved collected in standard acid. After the experiment is complete, the distillate is titrated with $\frac{N}{2}$ sodium carbonate using methyl orange as indicator, and from the amount of acid used, the percentage of nitrogen may be easily calculated with the aid of the following formula, where n = no. of c.cs. of $\frac{N}{2}$ acid neutralised by the ammonia; w = weight of malt extract taken, and x = percentage of nitrogen;

then $x = \frac{n \times 0.007 \times 100}{w}$, and assuming that 0.028 grm. nitrogen corresponds to 0.164 grm. of albumin or other protein matter, the percentage of the latter is given by $x \times 0.164 \div 0.028$.

The results of the examination of 13 commercial samples by Harrison and Gair are given in the table below. These samples were presumably obtained from stocks intended for edible purposes, but in any case there should be no wide differences between the results of analyses of well made malt extracts, whether used for dietetic or textile purposes, since the chief properties upon which their application depend in both cases are their diastatic and liquefactive powers. Of course, a high protein content in an extract used for dietetic purposes is of considerable importance, while it is objectionable from a textile standpoint, except in so far as it influences the liquefactive and saccharifying powers. The protein con-

tent in a good sample should be about 6 per cent. of the whole or 8 per cent. of the total solids. The amount of nitrogenous matter actually found, plus the amount of reducing sugars, (calculated as maltose), subtracted from the weight of total solids, gives a figure known as the dextrin figure. This corresponds to the amount of dextrin present, and varies from 9 to 14. When the figure is below 9, it is concluded that the extract has been adulterated with glucose, since the latter possesses a greater reducing power than maltose.

ANALYSES OF THIRTEEN COMMERCIAL MALT EXTRACTS.
(HARRISON AND GAIR.)

Sample.	Total Solids.	Maltose.	Protein Content.	Diastatic Power.	Remarks.
	Per cent.	Per cent.	Per cent.		
1.....	73·2	65·4	6·7	468	—
2.....	79·8	64·4	5·3	346	—
3.....	69·8	58·5	5·5	356	—
4.....	77·0	54·0	3·6	10	—
5.....	72·3	52·1	3·8	15	—
6.....	95·9	82·1	5·7	89	Solid extract.
7.....	76·8	66·0	6·1	96	A salicylate present in considerable amount.
8.....	74·3	62·5	6·1	65	Ditto.
9.....	73·0	47·1	3·8	17	9·5% cane sugar present.
10.....	66·2	49·7	3·9	0	—
11.....	78·7	74·2	5·5	268	High maltose figure; probably due to glucose.
12.....	64·9	8·58	3·9	0	—
13.....	73·9	63·[illegible]	6·6	137	—

SECTION II.—SOURING AGENTS.

The chief compounds belonging to this class are oxalic, acetic, formic, hydrochloric, and sulphuric acids. These are used in the operation of "souring," *i.e.*, acid treatment, a term that is commonly applied to any method of treating textile materials with weak cold acids during the processes of cleansing and bleaching. The

term " sours," appears to have originated in textile bleach-works, in which it is generally understood to mean a solution of hydrochloric, or sulphuric acid.

In modern laundry work, " souring " is usually carried on with the aid of a weak solution of oxalic, acetic, or formic acid. Its object is to decompose various compounds which have been formed on the fibres during the previous washing, or bleaching operations, the decomposition products being more readily removed in the subsequent rinsing operation than the original substances. In many trade laundries, " souring " takes place immediately before the bleaching operation, and, as this mode of procedure, is the reverse of that, which is universally adopted in the bleaching of grey cloth, it will be necessary to discuss the matter more fully when dealing with Trade Laundry Work.

Oxalic Acid, $H_2C_2O_4.2H_2O$.—This acid is usually made from cellulose (sawdust or wood pulp), by saturating it with strong caustic alkali, and heating the mixture at a high temperature for some time. The fused mass is then lixiviated with water, and the solution thus obtained, allowed to stand until the oxalates, etc., present, are deposited in the form of crystals. These are freed from impurities by first boiling them with lime, in order to effect their conversion into insoluble oxalate of lime. The latter is then collected, and washed, and subsequently boiled with sulphuric acid. Finally, the mixture is filtered to remove calcium sulphate, and the filtrate—*i.e.*, oxalic acid solution—concentrated and allowed to crystallise.

Oxalic acid occurs in the form of well defined white crystals containing two molecules of water of crystallisation. It is largely used in the laundry for " souring " purposes, as well as for removing certain kinds of stains from the different fibres.

Oxalic acid neutralises alkalies, and forms two series of salts, which are known as normal salts and acid salts respectively. The former are prepared by neutralising a solution of the acid with such alkalies as caustic potash, or caustic soda, while the latter are made by neutralising only one half, or one fourth of the amount of acid taken. The acid potassium salts are sometimes used in the laundry under the names of " salts of sorrel," or " salts of lemon," for removing iron and ink stains, but, as these compounds are not very soluble, there does not appear to be any advantage in using them in place of oxalic acid.

Commercial oxalic acid is rarely adulterated; the actual amount of acid present, may be found by titrating with normal caustic soda solution, 1 c.c. of which corresponds to 0.063 grm. of $H_2C_2O_4.2H_2O$, using phenolphthalein solution as indicator. *Example*:—2 grms. of commercial oxalic acid were dissolved in

200 c.cs. of water contained in a beaker, a few drops of phenolphthalein solution added, and normal caustic soda solution run in from a burette until a permanent pink colour was obtained, 31.2 c.cs. being required. Therefore, the amount of $H_2C_2O_4.2H_2O$ in 2 grms. of the sample = $31.2 \times 0.063 = 1.965$ grms., and the percentage amount =

$$\frac{1.965 \times 100}{2} = 98.2$$

Acetic Acid, $C_2H_4O_2$.—This acid is prepared on a large scale from the crude pyroligneous acid, which is obtained by the destructive distillation of wood. The crude acid is first distilled, and the vapour passed through milk of lime, whereby acetate of lime is formed, and various volatile impurities removed. The solution of lime acetate is next evaporated to dryness in iron pans, and the tarry matter which collects on the surface removed by skimming. Finally, the dry salt is distilled with concentrated hydrochloric acid from a copper retort, care being taken that excess of acid is not employed. The strong acetic acid which collects in the receiver is subsequently re-distilled, a small quantity of an oxidising agent, *e.g.*, potassium permanganate, or potassium dichromate being added to the contents of the retort, in order to oxidise impurities. The distillate thus obtained, constitutes the acetic acid of commerce. By further concentration and purification, glacial acetic acid is obtained, which is characterised by its property of solidifying on cooling to an ice-like mass.

Commercial acetic acid is a colourless pungent smelling liquid. It indicates about 8° on Twaddell's hydrometer, and contains about 29 per cent. of acetic acid. Its actual strength is best determined by weighing out 10-20 grms., diluting with water, and titrating with normal caustic soda solution, using phenolphthalein as indicator, 1 c.c. of $\frac{N}{1}$-NaOH = 0.06 grm. acetic acid.

Acetic acid is frequently used in the laundry for "souring" linen and cotton goods after the washing and bleaching processes. It possesses many advantages as a "souring" agent compared with oxalic acid, amongst which may be mentioned its property of forming soluble lime salts, and its inert nature as regards its behaviour towards fibres under practically all working conditions.

Formic Acid, CH_2O_2.—Formic acid is prepared on a large scale in Germany by the action of carbon monoxide on caustic soda under high pressure, and at a high temperature. It is sent out in different grades of strength containing from about 80-96 per cent. of acid. The pure acid boils at 100-101° C., and has a specific gravity of 1.22 at 20° C.

Formic acid possesses a highly pungent odour, is very volatile, blisters the skin, and forms a series of soluble salts termed formates. It is a stronger acid than acetic—indeed, it is one of the strongest organic acids—and can be used for practically all purposes for which the latter is employed. It has no detrimental action on vegetable, or animal fibres, under the usual working conditions.

Hydrochloric Acid, HCl; also known as *spirits of salt, muriatic acid,* and *marine acid.*—When common salt is heated with moderately strong sulphuric acid, a gas is evolved, to which the name of hydrochloric acid is given. This gas is very soluble in cold water, the solution obtained being also known as hydrochloric acid, although in commerce it is more commonly termed spirits of salt. Hydrochloric acid is sent out in carboys, *i.e.*, glass bottles encased in wrought iron baskets, which are lined with straw to prevent breakage. It is sometimes used in the laundry for "souring" purposes, and for removing iron stains which resist the usual reagents. Fibres treated with it, should always be thoroughly rinsed in water before drying.

Properties and Valuation.—Hydrochloric acid is a yellowish liquid which fumes in contact with the air; it possesses powerful acid properties, dissolves most metals, and neutralises alkalies with the formation of a series of salts known as chlorides. The value of a sample of the acid depends upon the actual amount of HCl present, the approximate amount of which can be determined by means of Twaddell's hydrometer, and reference to the table of specific gravities given at the end of the book. Hydrochloric acid is sometimes found to be adulterated with common salt; consequently, in such cases, the degree indicated by the hydrometer would afford no means of arriving at the correct strength of the acid. The presence of solid matter in solution may be easily detected by evaporating a small quantity of the acid to dryness in a porcelain dish; a distinct residue indicates the presence of solid matter, but if it is comparatively small in amount, the extent of the adulteration may be regarded as insignificant. Traces of iron are commonly present in samples of the commercial acid, but, in general, the amount present, seldom gives rise to faulty goods. The presence of iron is indicated if a deep blue precipitate or colouration is produced on mixing a little of the acid with a freshly prepared solution of potassium ferrocyanide.

Sulphuric Acid or **Oil of Vitriol,** H_2SO_4.—This acid is manufactured by introducing sulphur dioxide, nitrogen peroxide, steam, and air, into leaden chambers, in which the gases react with the formation of sulphuric acid and nitric oxide. The reaction may be represented in its simplest form by means of the following equa-

ion :—$SO_2+NO_2+H_2O=H_2SO_4+NO$. The nitric oxide is immediately oxidised to NO_2 by the oxygen of the air admitted into the chamber, as :—$2NO+O_2=2NO_2$, hence, a comparatively small quantity of NO_2 serves as a carrier of oxygen for the conversion of a very large amount of SO_2 into sulphuric acid. The acid which collects on the floors of the chambers is known as chamber acid. It is concentrated in leaden pans until it reaches a strength of about 146° Tw. Acid prepared in this way is frequently termed 'brown oil of vitriol,' (B.O.V.). Further concentration takes place in glass or iron pans, the commercial acid ultimately obtained having a strength of about 168° Tw. This is termed concentrated sulphuric acid or double oil of vitriol (D.O.V.).

Properties and Valuation.—Concentrated sulphuric acid is a colourless, odourless, oily liquid. It possesses a powerful affinity for water and when brought into contact with moist organic matter, *e.g.*, cotton or linen, charring takes place more or less readily, the elements of water being removed, and carbon left. It also dissolves many metals, and neutralises alkalies forming a series of salts known as sulphates. When the strong acid is mixed with water great heat is developed, and care should be taken to always pour the acid into the water and not *vice versa*.

Commercial sulphuric acid is seldom adulterated; its strength may be determined by means of Twaddell's hydrometer, and, if necessary, the degree thus obtained converted into the percentage amount of actual H_2SO_4 by reference to the table given in the appendix. Weak sulphuric acid is occasionally used by the launderer for "souring" cotton and linen goods, as well as for the preliminary treatment of certain kinds of embroideries. Its employment in the treatment of vegetable fibres should always be followed by thorough rinsing in water, as it is well known that traces of the weak acid ultimately exert a destructive action on cellulose under suitable conditions.

SECTION III.—WHITENING OR BLEACHING AGENTS.

The substances included in this section may be divided into two classes, viz.:—Oxidising agents and reducing agents. To the first class belong bleaching powder, sodium hypochlorite, "electrolytic bleach," sodium peroxide, potassium permanganate, sodium perborate, etc., while sulphurous acid and the recently introduced stable hydrosulphites, are the chief representatives of the second class. As a general rule, most textile fibres are bleached with oxidising agents, reducing agents being only employed in special cases. Apart from their use as bleaching agents proper, however,

the latter are of considerable service on account of their powerful action on many colour stains which are unaffected by oxidising agents, as well as for the treatment of fibres which have already been bleached with some of the members of the first group. The bleaching action of an oxidising agent depends upon the fact, that under suitable conditions it is capable of yielding nascent oxygen, which readily oxidises many organic colouring matters, converting them into colourless oxidation products. On the other hand, a reducing agent acts by yielding nascent hydrogen, which possesses the property of converting a considerable number of colouring matters into colourless reduction products, and in such cases, the permanence of the results is dependent upon the resistance of the reduction product, or products, towards atmospheric oxygen.

I.—OXIDISING AGENTS.

Bleaching Powder.—The most important solutions used for whitening vegetable fibres in the laundry are prepared either directly or indirectly from bleaching powder, which is manufactured on a large scale by allowing chlorine gas to act upon finely sieved slaked lime spread on the floor of specially constructed chambers. The gas is gradually absorbed by the lime, which is turned over from time to time, in order to expose all portions to the action of the chlorine. As soon as the absorption of gas ceases, finely powdered slaked lime is introduced into the chambers for the purpose of removing traces of chlorine which still remain unabsorbed, and the bleaching powder is subsequently introduced into casks. The quality of the product obtained in this way varies to a considerable extent, and depends chiefly upon the nature of the raw materials employed, and the care bestowed during the process of manufacture. The lime used is of the best quality; the chlorine is carefully freed from other gases, and the temperature is regulated during the absorption of the gas according to experience.

Bleaching powder belongs to the class of chemical compounds known as hypochlorites; it is frequently termed calcium chlorohypochlorite, to which has been assigned the chemical formula, $Ca\begin{matrix}OCl\\Cl\end{matrix}$. The commercial article, however, always contains a considerable quantity of unchanged slaked lime, as well as small quantities of other compounds. Bleaching powder is commonly known as chloride of lime, but the true chloride of lime possesses the formula $CaCl_2$, and its solutions do not possess bleaching properties.

Properties.—When bleaching powder is treated with water, a greater or less amount dissolves, and the clear solution which is obtained on allowing the mass to settle, contains calcium hypochlorite and calcium chloride, as well as small amounts of other substances, while the residue consists essentially of slaked lime. This action is represented by the following equation :—

$$2Ca\,OCl_2 = Ca\,Cl_2 + Ca(OCl)_2.$$

Bleaching-powder = calcium chloride + calcium hypochlorite.

A portion of the unchanged slaked lime (calcium hydrate), also dissolves in the water. Consequently, freshly prepared solutions of bleaching powder are always alkaline owing to the presence of this substance.

Bleaching powder occurs in commerce in the form of a fine white powder which smells of hypochlorous acid (HClO), according to some authorities, although Taylor maintains that chlorine only is slowly evolved in the presence of moist air containing carbon dioxide.

The decomposition of the commercial article is reduced to a minimum by storing it in tightly-closed casks.

Preparation of Stock Solution.—A stock solution of bleaching powder may be prepared by adding it in the form of fine powder to a suitable volume of water at about 70° F., contained in an earthenware vessel. Thorough stirring is essential, and should be continued for at least 10 minutes. The mixture is subsequently allowed to settle for about 24 hours, and the clear liquid filtered through a piece of calico into a stoneware bottle, and diluted until it indicates 12° on Twaddell's hydrometer. The bottle should be kept tightly corked. As only small quantities of the solution are usually required in laundries, the sludge produced is practically valueless.

Valuation of Bleaching Powder and other Hypochlorites.—The value of a sample of bleaching powder, or of a solution of any hypochlorite is dependent upon the amount of available chlorine present, *i.e.*, chlorine which is available for bleaching purposes, and which is evolved when the sample is acted upon by an acid.

A fresh sample of a well made bleaching powder contains from 35-36 per cent. of available chlorine, but a sample which has been badly made, or which has been exposed to the air for a considerable time will contain a much lower percentage. The actual amount present can only be accurately determined by a chemcial process since the determination of the density of an aqueous solution by means of a hydrometer does not constitute a reliable measure of the chlorine content.

Valuation by means of Potassium Iodide and a Standard Solution of Sodium Thiosulphate.—The available chlorine in hypochlorite solutions is now usually determined by means of the thiosulphate method, which may be conveniently carried out as follows:—

A standard solution of sodium thiosulphate, $Na_2S_2O_3.5H_2O$, (the "hypo" used by photographers), is first prepared by dissolving 21 grms. of the pure salt in distilled water contained in a litre flask, and subsequently making up to one litre with distilled water.

Each c.c. of this solution required to "neutralise" the available chlorine contained in 10 c.cs. of the hypochlorite solution to be tested, indicates 0.3 grm. of available chlorine per litre, or 21 grains per gallon.

10 c.cs. of the hypochlorite solution are introduced into a flask, along with a few c.cs. of water. About 2-3 c.cs. of a 10 per cent. solution of potassium iodide are then added with continual shaking. Iodine is liberated, and the liquid assumes a dark reddish tint. Finally, about 3-4 c.cs. of 30 per cent. acetic acid are added. The standard sodium thiosulphate is then added gradually from a burette—the liquid in the flask being constantly agitated—until the liquid becomes pale yellow; a few drops of cold starch mucilage are added at this stage, the liquid assuming a dark blue colour. More sodium thiosulphate is then added until one drop completely decolourises the liquid.

Example:—10 c.cs. of bleaching liquor were taken and mixed with 4 c.cs. of water + 3 c.cs. of potassium iodide solution (10 grms. in 100 c.cs. of water). Eight c.cs of standard sodium thiosulphate were required to decolourise the liquid. Therefore, as 1 c.c. of the standard thiosulphate added to 10 c.cs. of bleaching liquor corresponds to 21 grains of available chlorine per gallon, the sample tested contains $21 \times 8 = 168$ grains of active chlorine in one gallon.

Uses of Bleaching-Powder Solution.—A solution of bleaching-powder is occasionally used by launderers for the removal of stains, and for whitening or bleaching vegetable fibres during the process of cleansing. Its chief use in the laundry, however, is for the preparation of sodium hypochlorite.

Only weak solutions should be employed in all cases of stain removing, or bleaching, and the treated goods should be afterwards well washed, dipped into weak acetic, or hydrochloric acid, and thoroughly rinsed again.

A solution of bleaching-powder should not be used in conjunction with soap, as the latter forms sticky insoluble "soaps" with solutions of calcium salts, and the production of such "soaps,"

in presence of fibrous materials ultimately gives rise to serious defects.

Sodium Hypochlorite.—This compound, which is known in the North of Ireland as "*alkali-dip*," is usually made by adding a cold solution of "pure," or "refined alkali," to a cold solution of bleaching-powder until no further precipitation takes place. Sodium sulphate may be used instead of "alkali."

The principal chemical action which takes place may be represented by the following equation :—

$$\underset{\substack{\text{Active ingredient in}\\ \text{bleaching-powder solution}}}{Ca(OCl)_2} + Na_2CO_3 = CaCO_3 + 2NaOCl.$$

Calcium hypochlorite + sodium carbonate = calcium carbonate + sodium hypochlorite.

The usual mode of procedure when making small quantities of the solution is indicated in the following example :—

Introduce 10 lbs. of bleaching-powder into a suitable vessel, (wood or earthenware), and grind into a paste with about 6 gallons of water, added gradually. Then add 6 lbs. of "alkali," previously dissolved in about 4 gallons of water. Mix thoroughly, and allow the precipitated carbonate of lime to settle. Decant the clear liquor, filter through cloth if necessary, and reduce to 14° Tw. by the addition of water. The solution should be stored in glass carboys, and it may be kept for a long time without any appreciable loss in strength.

Sodium hypochlorite solution—if properly made—does not yield a precipitate with soap; on this account, it is extensively used in the laundry industry for bleaching linen and cotton goods during the actual washing process. It is also frequently employed at the ordinary temperature in separate baths. The liquid is sent out by manufacturers in glass carboys, and its strength, as measured by Twaddell's hydrometer, is usually about 14°. It is advisable, however, to determine the amount of available chlorine present in each delivery according to the method given under bleaching-powder.

Many of the liquid bleaches on the market consist essentially of solutions of sodium hypochlorite, containing small amounts of other sodium salts.

"**Electrolytic Bleaching Liquor.**"—Sodium hypochlorite may also be prepared by passing a current of electricity through brine. In this case, excess of brine, and small quantities of other salts are present in the liquor.

The decomposition of brine (NaCl) by the electric current can be readily demonstrated by introducing two pieces of platinum foil into a small quantity of the liquid contained in a beaker. One piece of the foil is connected to the positive pole and the other to

the negative pole of a suitable battery. A few drops of a solution of phenolphthalein are then added to the brine, when it will be observed that a red colouration is produced in the vicinity of the negative electrode, thus showing that an alkaline substance has been formed.

If the current be passed for a few minutes, or the liquid agitated, the red colour disappears. These changes are explained as follows:—The current of electricity enters the brine at the anode or positive electrode; it then passes through the brine and leaves at the cathode or negative electrode. During its passage through the brine, a certain amount of the latter is decomposed with the formation of sodium (Na), and chlorine (Cl). Some of the water contained in the brine is also decomposed into hydroxyl (OH), and hydrogen. The sodium and hydrogen pass with the current to the negative electrode where the hydrogen is liberated, but the sodium is immediately acted upon by the water in the brine, with the result that more hydrogen gas is evolved and a weak solution of caustic soda left in the liquid. Consequently, phenolphthalein solution becomes red in the neighbourhood of the negative electrode.

The chlorine and hydroxyl form hypochlorous acid (HOCl), at the positive electrode, but if the brine is agitated so as to bring the substances formed at each electrode into contact, another chemical action takes place and sodium hypochlorite (NaClO) is formed, which bleaches the red colour produced by the phenolphthalein in presence of caustic soda. The chemical reactions which take place may be expressed by means of the following equations:—

(1). $2NaCl = Na_2 + Cl_2$.
Brine (sodium chloride) = sodium + chlorine.

(2). $2Na + 2H_2O = 2NaOH + H_2$.
Sodium + water = caustic soda + hydrogen.

(3). $2H_2O = 2HO + H_2$.
Water = hydroxyl + hydrogen.

(4). $2HO + Cl_2 = 2HOCl$.
Hydroxyl + chlorine = hypochlorous acid.

(5). $2HOCl + 2NaOH = 2NaOCl + 2H_2O$.
Hypochlorous acid + caustic soda = sodium hypochlorite + water.

Although the above reactions represent, theoretically, the principal chemical changes which occur during the electrolysis of brine, it is found in practice that several other reactions take place at the same time, and compounds are formed which are of no use for bleaching purposes.

Electrolytic Apparatus.—For the production of electrolytic sodium hypochlorite numerous types of electrolysers are available, but we shall only describe here the Haas and Oettel apparatus, a small size of which has been specially introduced for use in laundries. It consists of a tank of glazed stoneware containing brine, in which is placed the box shaped electrolyser shown in Fig. 7. The electrolyser is sub-divided by means of carbon plates into numerous chambers or cells. The first and last carbons constitute the anode and cathode respectively. Each cell has no communication with its neighbour, but has an opening at the bottom communicating with the brine tank, and an overflow pipe at the top. Hence, when

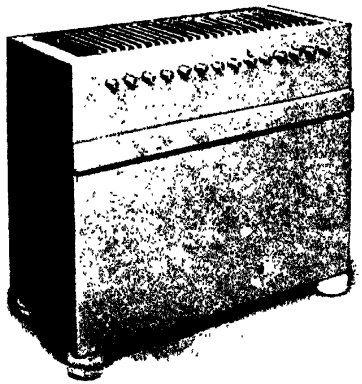


FIG. 7. HAAS-OETTEL ELECTROLYSER.
(E. Grether and Co.).

the tank is filled with brine to the level of the series of overflow pipes, communication is established between them and the brine in the tank.

On sending a current of electricity through the apparatus, the liquor in the electrolyser effervesces strongly, and rises to a higher level than the brine in the tank. Consequently, a certain volume of partially electrolysed brine flows through the overflow pipes, while a corresponding volume of cool brine enters the electrolyser by means of the openings at the bottom. The fresh brine then rises in the cells, becomes partially electrolysed and overflows as before, thus creating an automatic circulation.

The effervescence is caused by the liberation of hydrogen, which passes through the brine on its way to the atmosphere. Hence, the liquor in each cell is lighter than that in the tank owing to the presence of innumerable bubbles of gas. The temperature

is kept below 28° C., by passing a continuous current of cold wate through a coil of piping contained in the outer tank. When in us the electrolyser is generally erected on a platform about four fee from the ground, in order to allow the electrolysed liquor to b drawn off into suitable vessels. On another platform above th electrolyser, is the brine tank, in which the brine is made once day and then run into the electrolyser as required by means of lead pipe. The complete apparatus is shown in Fig. 8. The typ of electrolyser recommended for use in laundries requires a con

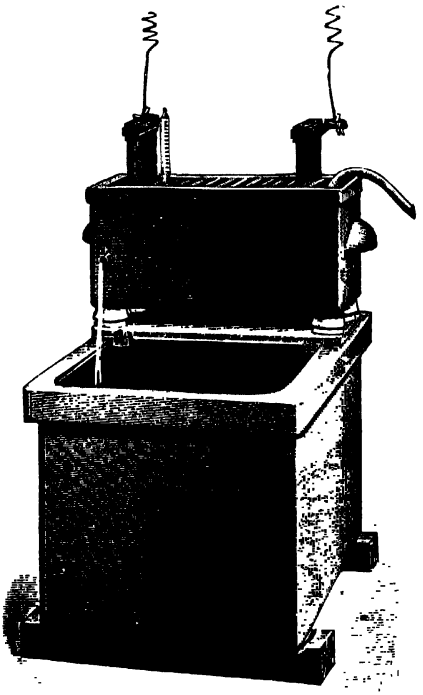


FIG. 8. ELECTROLYSER AND STORAGE TANK.
(E. Grether and Co.).

tinuous current of 110 volts × 12 ampères. If, however, a current of 220 volts is already used for other purposes, it is necessary to couple two electrolysers in series; or a small dynamo may be used. With a current of the above strength, the electrolyser supplies

in 10 hours, from 110-132 gallons of liquor containing 210 grains of active chlorine per gallon. For use, the liquor is diluted until it possesses a strength of 70 grains active chlorine per gallon.

It may be used in the laundry for the same purposes and in the same way as the liquid prepared by the double decomposition of bleaching powder solution and sodium carbonate, to which reference has already been made. About 3-4 gallons of the diluted liquor (70 grains strength), are required for every 112 lbs. (dry weight), of "linen."

Electrolysed brine is now regularly used in many of the large laundries and hospitals for whitening "linen," as well as for disinfecting purposes. Its actual strength may be ascertained by the method given on page 66.

Hydrogen Peroxide, H_2O_2.—This substance is prepared by decomposing barium peroxide, BaO_2, suspended in water by means of sulphuric or carbonic acid and decanting the solution of H_2O_2 from the precipitate which forms. It is usually sent into the market as a weak solution containing from 3-6 per cent. of H_2O_2. The strength of the commercial article is indicated by such terms as hydrogen peroxide (10 vols), (12 vols), etc., which mean that a given volume of the liquid contains 10 or 12 times its volume of oxygen available for oxidising purposes. On account of its bulky nature and instability commercial hydrogen peroxide is not now used for bleaching purposes except in a few special cases. It is finding more and more extensive use, however, when generated from sodium peroxide or the perborates.

Sodium Peroxide, Na_2O_2.—Peroxide of sodium is manufactured by subjecting slices of metallic sodium—heated to a temperature of 300-400° C.—to the action of purified air. It occurs in commerce in the form of a yellowish-white deliquescent powder which absorbs carbon dioxide from the air liberating oxygen. In contact with water, sodium peroxide develops great heat forming caustic soda and hydrogen peroxide; the latter is more or less completely decomposed under the influence of the heat generated unless the temperature is kept below about 35° C. during dissolution of the powder. These changes may be represented as follows:—

$$Na_2O_2 + 2H_2O = 2NaOH + H_2O_2.$$

Sodium peroxide + water = caustic soda + hydrogen peroxide.

$$2H_2O_2 = 2H_2O + O_2.$$

Sodium peroxide is a powerful oxidising agent, and as it readily attacks organic matter, it should always be kept in tightly closed lead or glass vessels. It yields hydrogen peroxide when added to weak acids together with the sodium salt of the acid

employed. A solution prepared in this way is commonly used for bleaching wool and silk. The reaction is as follows:—$Na_2O_2 + H_2SO_4 = Na_2SO_4 + H_2O_2$.

Salts of Perboric Acid.—During the last few years several salts of the hypothetical perboric acid, HBO_3, have been introduced for bleaching purposes in the laundry. Among these the best known is sodium perborate which may be obtained in a pure form but is often sold mixed with other substances under various fancy names. Crystalline sodium perborates have been prepared by Braht and Dubois by precipitating a solution of sodium borate in hydrogen peroxide with alcohol, or by electrolysing a solution of sodium orthoborate. By these methods, salts of different composition have been obtained such as the following:—$NaBO_3.H_2O$, $NaBO_3.2H_2O$, $NaBO_3.3H_2O$, and $NaBO_3.4H_2O$. When heated or dissolved in hot water they undergo decomposition with the evolution of nascent oxygen. If the water is not too hot, hydrogen peroxide is formed. The anhydrous salt $NaBO_3$ has also been prepared; it contains about 20 per cent. of available oxygen and is fairly stable when kept dry and at a low temperature. In presence of moisture or heat, however, it is readily decomposed.

Different methods for the preparation of alkali perborates on a commercial scale have been patented. In one case a mixture of sodium peroxide and powdered boric acid is added to weak cold sulphuric acid the temperature being kept low during the addition of the mixture. Jaubert carries out the process in two stages, (*Jour. Soc. Chem. Industry*, 1904, *p.* 1145), by first adding the mixture of sodium peroxide and boric acid to cold water, whereby crystals having the composition $Na_2B_4O_8.10H_2O$ are thrown down, and secondly, dissolving the crystals in water and adding sufficient sulphuric acid to neutralise half the sodium present, when crystals of sodium perborate having the composition $NaBO_3.4H_2O$ are deposited and may be filtered off, washed with cold water and dried by exposure to air.

Another method is to add sodium peroxide gradually to ice cold water and then to carbonate the alkaline liquid by passing through it waste gases containing CO_2. Sodium meta-borate solution, (prepared from caustic soda and boric acid), is next added when a precipitate of sodium perborate is obtained. The substance is recovered by filtration and subsequently dried. Many of the "perborates" sold for laundry work contain varying amounts of other substances, some of which possess detergent properties, while others are of an inert nature. These additions render the perborates, more stable—especially in presence of moisture—since the amount of active oxygen which is capable of being liberated from a mixture is considerably lower than from the

unadulterated article. In many cases adulteration is adopted for economic reasons.

The detergents frequently found in commercial perborate preparations are soap, sodium carbonate, and sodium silicate. The presence of one or more of these is an indication that the actual amount of perborate present is comparatively small; hence, as the value of such preparations when used for bleaching purposes is dependent upon their active oxygen content, it will be evident that a preparation should be employed, the active oxygen content of which is stated by the maker.

A good sample of commercial sodium perborate should contain about 10 per cent. of available oxygen, as :—

$$8NaBO_3.4H_2O+4H_2O=2Na_2B_4O_7+4NaOH+2H_2O_2+3O_2+32H_2O.$$

Potassium Permanganate, $K_2Mn_2O_8$.—This substance is one of the most powerful oxidising agents available. It occurs in commerce in the form of small dark crystals which exhibit a peculiar lustre. Potassium permanganate is manufactured by fusing manganese dioxide, MnO_2, with caustic potash in the presence of an oxidising agent, and then dissolving the fused mass, (manganate of potash), in a large quantity of water, whereby decomposition takes place with the formation of the permanganate; the reactions are as follows :—

$$2MnO_2+4KOH+O_2=2K_2MnO_4+2H_2O.$$
$$3K_2MnO_4+2H_2O=2KMnO_4+4KOH+MnO_2.$$

The manganate remains unchanged in presence of excess of alkali.

Potassium permanganate yields nascent oxygen with great readiness when brought into contact with oxidisable substances; at the same time it deposits a brown hydrated oxide of manganese which may be subsequently removed by means of a solution of sodium bisulphite. A solution of potassium permanganate is occasionally used in the laundry for bleaching purposes, and for the removal of stains; it should be rendered slightly acid by the addition of sulphuric or acetic acid.

2.—REDUCING AGENTS.

Sulphur Dioxide, SO_2.—When sulphur is burnt in air, the product is a heavy, colourless, pungent smelling gas, which readily dissolves in water yielding a solution of sulphurous acid. These changes may be represented by the following equations :—

(1). $S+O_2=SO_2$. (2). $SO_2+H_2O=H_2SO_3$.

Sulphur dioxide is used to a considerable extent for bleaching or "stoving" certain kinds of woollen goods, straw, feathers, etc. Its aqueous solution is also of great service in many textile opera-

tions, but owing to the inconvenience of making it direct from the gas and water, it is generally prepared in the works by the addition of an acid to sodium bisulphite as described in the paragraph below. Sulphur dioxide is also occasionally used as a disinfectant

Sodium Bisulphite, $NaHSO_3$.—This compound is prepared by passing sulphur dioxide into a hot solution of sodium carbonate. The reaction which takes place may be represented as follows :—

$$Na_2CO_3 + 2SO_2 + H_2O = 2NaHSO_3 + CO_2.$$

Sodium bisulphite is usually sent into the market in the form of a liquid which indicates from 52°-80° on Twaddell's hydrometer. It is used as an antichlor, *i.e.*, for converting traces of chlorine or hypochlorites—which are sometimes present on bleached goods owing to inefficient washing—into salts which have no injurious action on cellulose fibres. Sodium bisulphite is also used for the purpose of decomposing and removing the brown oxide of manganese deposited on the fibre during the permanganate bleaching process. By adding a weak acid to a solution of sodium bisulphite, a solution of sulphurous acid, plus the sodium salt of the acid employed is obtained, as :—

$$2NaHSO_3 + H_2SO_4 = Na_2SO_4 + 2H_2O.SO_2.$$

This solution is generally employed for textile and other processes instead of sulphurous acid alone, on account of the simplicity of its production.

Sodium Hydrosulphite, $Na_2S_2O_4$.—A solution of sodium hydrosulphite together with zinc and sodium sulphites is obtained —according to Bernthsen—when sodium bisulphite is reduced with zinc dust, as :—

$$4NaHSO_3 + Zn = Na_2S_2O_4 + ZnSO_3 + Na_2SO_3 + 2H_2O.$$

It is a much more powerful reducing agent than the bisulphite, and has long been used in the preparation of indigo vats, and for discharging dyes in calico and silk printing. Solutions of sodium hydrosulphite are very unstable and their preparation according to the above method takes up a considerable amount of time. Under the general name of "hydrosulphites," however, there are now on the market several hydrosulphite compounds which are comparatively stable at the ordinary temperature, but readily decompose in presence of steam or acids, yielding free hydrosulphurous acid which is an extremely powerful reducing agent.

An anhydrous form of $Na_2S_2O_4$ has been introduced under the name of Hydrosulphite conc. B.A.S.F. It slowly decomposes in presence of moisture, but in other respects it is comparatively stable.

Sddium Sulphoxylate Formaldehyde, $NaHSO_2.CH_2O.2H_2O$ —Hydrosulphite N.F. extra (M.L.B.). Hyraldite C. extra (C.). Rongalite C., (B.A.S.F.).—This substance is a derivative of sodium hydrosulphite and may be obtained by acting upon the latter with formaldehyde. It belongs to a class of compounds, the members of which are characterised by great stability when compared with the hydrosulphites. They resemble the latter in that they possess extremely powerful reducing properties. According to Baumann, Thesman, and Frossard, (*Jour. Soc. Dyers and Colourists, 1905, p. 14*), the substance obtained by the action of sodium hydrosulphite on formaldehyde consists of equal molecules of the formaldehyde compounds of sodium sulphoxylate $NaHSO_2$, and of sodium bisulphite. It is prepared commercially by acting upon sodium bisulphite with zinc dust at an elevated temperature, in presence of formaldehyde and an acid. The sodium hydrosulphite compound is subsequently separated from the solution by crystallisation.

Sodium sulphoxylate formaldehyde or hydrosulphite formaldehyde, as it is often termed, finds a limited use in the laundry for the local treatment of articles which have been stained by dyes. A little of the powder is sprinkled on the stains and then moistened with acetic or formic acid. Decomposition of the substance takes place very quickly—especially if the stained material is gently warmed—and at the same time the dye is decolourised, *i.e.*, if it is sensitive to strong reducing agents.

Basic Zinc Sulphoxylate Formaldehyde, $(ZnOH)HSO_2.H.CHO$. —This compound is known in commerce as Decroline, Hyraldite Z, or Hydrosulphite A.Z. It occurs in the form of a heavy grey powder, insoluble in water, but readily soluble in acids; it is much more stable than the sodium compound mentioned above, and is completely decomposed only in boiling acid solutions. The substance now finds extensive use amongst dyers and cleaners for stripping purposes, and for removing dye stains from textile materials. Either formic or acetic acid is commonly employed to effect its solution. The powder is not appreciably affected by exposure to air, and may be stored for a long time if it is kept in a dry place.

Sodium Thiosulphate, $Na_2S_2O_3.5H_2O$—"Hypo."—Sodium thiosulphate may be prepared by dissolving sulphur in a solution of sodium sulphite, but it is usually manufactured from alkali waste. It is very soluble in water, and its aqueous solution possesses strong reducing properties. Sodium thiosulphate is largely used in volumetric analysis; it is also employed to a considerable extent in the treatment of vegetable fibres after the bleaching process, for the purpose of converting traces of free

chlorine which may not have been removed, into a neutral salt. When used in this way it is known as an "antichlor."

Titanous Chloride, $TiCl_3$, and **Titanous Sulphate,** $Ti_2(SO_4)_3$.—These substances are sent out in the form of heavy dark acid liquids, which possess extremely powerful reducing properties. Titanous salts—especially the chloride—are frequently used for stripping purposes, and for removing dye stains from vegetable fibres. Hydrochloric acid is added to the solution in order to prevent the precipitation of insoluble titanic hydrate which is apt to soil the goods.

SECTION IV.—FINISHING MATERIALS.

The finishing materials used in laundry work may be conveniently divided into the following groups:—

1. Stiffening Materials.
2. Lustreing Materials.
3. Softening Agents.
4. Blueing Materials.
5. Weighting or Filling Materials.
6. Antiseptics.

1.—STIFFENING MATERIALS.

Starch, $(C_6H_{10}O_5)n$.—The most important substance belonging to this class of materials is starch, the chief varieties used being rice, maize, potato, wheat, and cassava. Starch occurs in commerce in the form of a white, glistening, tasteless powder or short brittle "sticks" or "crystals." It is a product of the vegetable kingdom and is present in greater or less amount in the fruit, seed, and tubers or roots of many plants. Starch is never found in a pure state in nature, but is always associated with variable quantities of nitrogenous matter, *e.g.*, gluten, fat, etc., which are removed along with the husks by processes of steeping, grinding with water, sieving, and settling; the starch being ultimately obtained in the form of a thick sediment at the bottom of the settling vessels. A small quantity of caustic soda is usually added to the mixture in order to facilitate the separation of the gluten and fatty impurities. The latter are emulsified and the gluten swells by the action of the caustic soda so that when the treated mixture is caused to flow along suitable narrow channels a large proportion of the starch is deposited while most of the impurities are carried forward. The inefficient separation of the nitrogenous matter from starch during the process of manufacture renders it more liable to develop mildew under suitable conditions.

When starch is examined under the microscope it exhibits an appearance of small well defined granules of more or less regular shape. In most cases the granules appear to be built up in layers or strata round a comparatively small point or hilium. Moreover, the structure and shape of the granules of one kind of starch differ to a greater or less extent from those of other kinds, so that these peculiar features are of considerable service in distinguishing between the various starches.

The microscopical characteristics of various starches have been tabulated by Archbold, (*Jour. Soc. Chem. Industry, 1903, p. 64*), as follows :—

Name	Outline.	Measurement in mm.	Surface.	Hilium.	Markings.
Maize.	Rectilineal and polygonal.	1/70.	Uneven and slightly concave.	Stellate or irregular. Large centre.	None.
Rice.	Ditto.	1/250	Flat.	None.	None.
Potato.	Oval or elliptical.	1/25 long diam. 1/37 short ,,	Uniformly but slightly convex.	Dark spot near the narrow end.	Concentric rings, closed or almost closed curves.
Wheat.	Circular or nearly so.	1/50.	Convex.	Dark spot eccentric.	Occasionally a few exceedingly faint concentric rings.
Cassava.	Rectilineal and polygonal.	1/70.	Uneven and slightly concave.	Stellate or irregular. Large centre.	None.
Arrowroot. (Bermuda).	Oval.	1/28 long diam. 1/45 short ,,	Uniformly but slightly convex.	Nearer broad end circular, crucial transverse line or slit.	Faint concentric rings in few cases extending about 2/3 length of granule.

A starch granule consists of an outer envelope of a varying degree of thickness enclosing a substance known as granulose. The outer covering has the same chemical formula as cotton and linen, but it is non-fibrous, and is called starch cellulose to distinguish it from the cellulose of fibres.

Starch is not appreciably affected by cold water, but if the water be heated, the outer coverings of the starch granules are ruptured, and a thick pasty mass is formed commonly known as starch paste.

A test employed for the detection of the latter on various materials is based upon the fact that it acquires a blue colour in presence of a weak solution of iodine. The test is extremely delicate, but it should be carried out in the cold.

It has been shown by many authorities that the temperature at which the granules of starch burst when heated with water, is not the same for all starches, for example:—The granules of wheat starch burst at 63°-64° C., those of rice at about 74° C. Maize starch granules burst at about 68°-70°C., and those of potato starch at 62°-63° C. It would appear from the above that the long boiling which starch undergoes in many laundries, in which boiled starch is used, is unnecessary, but it does not follow, however, that the whole of the granules in a mixture of starch and water burst at the same time, or at the same temperature; hence, the method adopted in practice is logical, in so far as it has for its object, the disruption of the whole of the starch granules in order to produce a homogeneous paste.

Starch readily absorbs moisture from the atmosphere, and under ordinary conditions it contains about 18 per cent. of water.

Maize Starch.—This is obtained from maize or Indian corn which contains about 65 per cent. If intended for use in the finishing of textiles it is separated from the husks and other impurities as follows:—

The Indian corn is first steeped in water at a temperature of about 120° F., for two days. It is then ground with water between mill-stones and the milky liquid passed through a sieve to remove the husks. The liquid passes from the sieve into wooden channels in which a considerable amount of starch is deposited, the gluten and other impurities, as well as excess of starch passing into a large settling tank. The starch which has settled out in the channels is placed in a large tank which contains water and is provided with mechanical agitators; a small quantity of caustic soda is then added, and after thorough agitation the mixture is passed over the channels again, where the starch is deposited in an almost pure condition. It is next introduced into another tank containing water, and washed by decantation. The mixture is then pumped into perforated boxes covered with fine cloth, upon which the starch is deposited. Finally, it is collected, dried carefully in hot flues, and in many cases broken up into lumps or "crystals," in which form it is sent into the market.

Maize starch is used in enormous quantities for finishing all kinds of cotton and linen goods. When boiled with water it yields a thicker paste than any other starch and the separation of water and starch on standing does not readily take place. Articles which have been finished with maize starch possess a stiff and thick "feel," but not so much pliability. It is largely used, however, in laundries in which the cold or raw starch process is carried on, while thin-boiling maize starch is commonly employed in the boiled-starch process.

The granules of maize starch (Fig. 9), are more or less circular in shape and vary in size to a considerable extent.

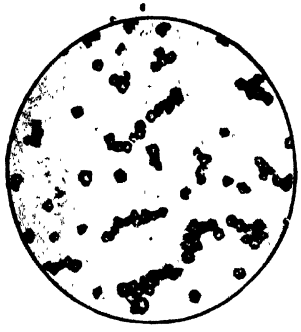
Rice Starch.—As its name implies, rice starch is obtained from the rice plant, *Oryza sativa*, being present in the seed to the extent of about 75-80 per cent. It is used in very large quantities in the laundry industry both in the raw starch process and in the form of a partially hydrolysed or thin-boiling starch. Rice starch produces a firm hard "feel" on goods finished with its aid, and yields more pliable work than maize starch. It is more expensive, however, than the latter.

The appearance of rice starch granules under the microscope is shown in Fig. 9. They are pentagonal or hexagonal in shape and are smaller than those of other starches; hence, it is often stated that rice starch suspended in water will penetrate textile fibres with greater facility and in a more uniform manner than all other starches.

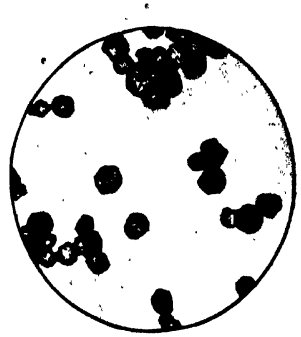
Potato Starch or **Farina.**—This is obtained from the potato, in which it is present to the extent of from 15-20 per cent. The potato is cultivated on an enormous scale in Germany and Holland for the requirements of the starch industry. More attention has been given to the manufacture of starch from potatoes in Germany than in most other countries, with the result that German farina is considered to be the best variety of potato starch. It yields a thick paste with water, which possesses strong adhesive properties. Large quantities of potato starch are used in the laundry industry for the preparation of boiled starch pastes, which are chiefly used for light starching. Farina pastes exhibit a tendency to liquefy on exposure to the air for some time. The granules (Fig. 9), are larger than those of any other starch. Potato starch is often used as an adulterant.

Wheaten Starch.—The manufacture of starch from wheat has been carried on from very early times, and considerable quantities are still made. Owing to the expense of the raw material, however, wheaten starch is not now used for trade purposes to such a great extent as those already mentioned, although it is often used in new work laundries in conjunction with rice and maize starches, for producing stiff and pliable work. Goods finished with wheaten starch possess a moderately stiff "feel" and a considerable amount of pliability.

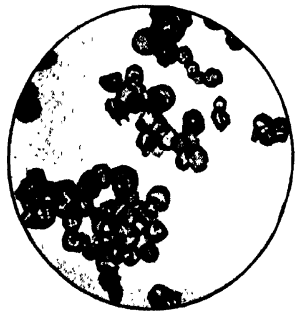
In addition to the starches mentioned above, there are many other less known varieties on the market; among these may be mentioned *tapioca* or *cassava*, obtained from the tubers of cassava or manihot; *sago*, derived from the pith of the sago-palm, and *arrow-root*, obtained from tropical plants belonging to various species of maranta.



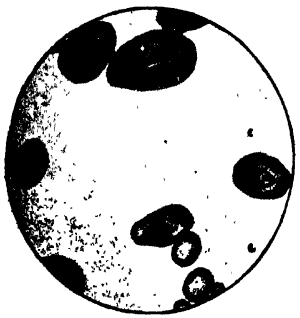
Rice starch. 150 diam.



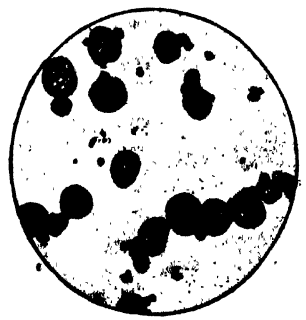
Maize starch. 150 diam.



Cassava starch. 150 diam.



Potato starch. 150 diam



Wheat starch. 150 diam.

FIG. 9. MICROSCOPICAL APPEARANCE OF VARIOUS STARCHES
(From micrographs by E. Clayton).

None of these appears to be used to any great extent in laundry work, but it is highly probable, that sooner or later, they will find extensive application in the various finishing industries.

Cassava starch has been on the market for many years, and has met with a considerable measure of success in certain branches of textile finishing. It is imported from Jamaica in the form of a fine powder, or "crystals," thus differing in the latter respect, from both potato and arrowroot starches, which fall to a fine powder or assume the granular form on drying. Cassava starch resembles maize starch in many of its properties, although it does not appear to be capable of imparting the same degree of stiffness to cotton and linen as the latter. In spite of its low stiffening power, however, it is gradually displacing maize starch in many finishing processes, presumably on account of its lower cost and its property of yielding a mellow "finish."

Cassava starch can be readily distinguished from other starches by means of its microscopical appearance, as shown in Fig. 9.

Valuation of Starch.—The value of a sample of starch for laundry work depends principally upon its stiffening and adhesive properties; its colour; nature of paste obtained on heating with water; freedom from albuminous matter, and other factors. Consequently, the relative values of different samples are best determined by actual trials in the laundry.

It is not possible to deduce the value of a starch for finishing purposes from the results of chemical analysis, although the determination of moisture, ash, and nitrogenous matter, affords an indication of its purity. The percentage amount of ash in a pure starch should not exceed 0.2—0.5 per cent., while the amount of moisture in an air-dried sample should not exceed 18 per cent. The latter may be determined according to the method described under soap, and the ash as follows:—

Determination of Mineral Matter.—Weigh out about 1-2 grms. of starch in a porcelain crucible of known weight. Place the crucible and contents on a pipe-clay triangle supported by a tripod stand, and heat gently by means of a non-luminous flame. The starch will begin to swell and the heat should be carefully regulated in order to prevent loss owing to some of the substance passing over the sides of the crucible. When the moisture has been removed, charring begins, and most of the charred mass is finally converted into gaseous matter by long heating over a powerful burner, while the mineral ash is left in the form of a white powder. The crucible and contents are then cooled and weighed, and the percentage amount of ash calculated in the usual manner.

The results obtained by the analyses of the chief starches are given below in tabular form:—

	Starch.	Water.	Cellulose.	Ash.	Analyst.
Maize Starch ..	81·6	17·5	0·65	0·25	McKerrow.
Rice	80·75	18·42	0·76	0·07	Davis & Dreyfus.
Potato	81·31	17 8	0·34	0·55	McKerrow.
Wheaten	81·12	16·5	2·3	0·08	Graham.
,, ...	82·03	16·9	1·0	0·07	Davis & Dreyfus.

Thin-boiling Starches.—If ordinary starch paste is boiled for some time, the starch-cellulose is gradually converted into a mixture of soluble substances which latter are closely allied to the dextrins. It is well known that these bodies readily dissolve in water, yielding pastes of low viscosities; hence, it is evident that the greater the degree of the conversion of the starch contained in ordinary starch paste, the lower will be the viscosity of the latter, or in other words the thinner it becomes. This thinning action, which takes place on boiling, is counterbalanced to a certain extent by the evaporation of water from the mixture during the boiling process, (*i.e.*, when a closed steam coil is employed for heating), so that in such cases the ultimate effect of long boiling on the viscosity of the paste is not very pronounced in practice.

If certain impurities are present in the paste, however, or if a little acetic acid is added, and boiling continued for a short time, the resultant paste will be much thinner than a paste made in the ordinary way from pure materials. The longer the paste is boiled—within reasonable limits—under such conditions, the thinner it becomes, this effect being brought about by the gradual conversion of the starch-cellulose into soluble derivatives. Starch which has been changed in this way is said to have undergone partial hydrolysis, which latter term is used to indicate a chemical change brought about by the addition of the elements of water to the substance concerned. When acid is employed to facilitate the conversion of the starch, the process is nown as acid-hydrolysis.

The fact that partially hydrolysed starch yields a thin paste when boiled with water, is utilised by starch manufacturers in the production of so-called thin-boiling starches, which are used to a very large extent in the laundry industry, especially in the United States of America. The conversion of starch into a thin boiling product, is commonly effected with the aid either of mineral or organic acids—generally the former—, the degree of hydrolysis of the starch-cellulose being governed by the nature and amount of the acid employed, as well as upon the temperature

and length of time of the subsequent drying operation. Malt extract may be used instead of acids for effecting the conversion of starch as already mentioned in a previous section. When acid is employed, the usual mode of procedure is as follows:—The starch suspended in water, is mixed with a very small quantity of acid and the mixture allowed to stand,—or it may be filtered—in order to separate the starch from the weak acid liquid. The pasty mass is then dried in a suitable room, the temperature of which can be easily regulated. As a rule, the temperature is not allowed to exceed 150° F. Finally, traces of acid should be removed by a thorough washing process.

It is sometimes stated that thin-boiling starches are definite mixtures of unaltered starch and dextrin, but it is difficult to conceive how only a portion of a mass of starch in presence of an acid is converted into dextrin, while the remainder is practically unaffected, unless we assume that the acid exerts a selective attraction towards the small or not fully developed granules. In any case, it is well known that other decomposition products of starch are present in thin-boiling starches, in addition to dextrin, *e.g.*, reducing sugars such as dextrose; while, if diastase (malt-extract), is employed for the conversion of the starch instead of acid, one of the products is the reducing sugar termed maltose. It is evident, therefore, that during the conversion of starch, according to the process described above, a portion, at least, undergoes complete hydrolysis, dextrin being produced as an intermediate product. This change may be represented as follows:—

(1). $(C_6H_{10}O_5)n \xrightarrow[\text{Starch}]{} \underset{\text{dextrin.}}{(C_6H_{10}O_5)n}.$

(2). $(C_6H_{10}O_5)n + nH_2O = n\underset{\text{dextrose or glucose.}}{(C_6H_{12}O_6)}.$

It is of interest to note that the chemical changes which occur during the conversion of starch into its thin-boiling modification, are not accompanied by any pronounced alteration in the ordinary physical characteristics of the starch, such as colour, etc., and the granules exhibit practically the same appearance under the microscope as those of the unaltered starch.

The advantages of thin-boiling starches for finishing several-ply articles which need to be highly stiffened, as compared with ordinary starch, depend upon the fact that the pastes they yield with water penetrate fibrous materials more or less readily, and in sufficient amount to yield a certain degree of stiffness on ironing. Indeed, it may be here mentioned that the introduction of starches of this nature, appears to have been due to the demand for a stiffening material, which could be used with success in

machines specially designed for the purpose of impregnating goods composed of many folds of cloth with a considerable amount of starch in the course of a few seconds. It is well known that when thin-boiling starches were first introduced, different batches of the same kind of starch often yielded pastes of varying degrees of consistency, although the amounts of water and starch were the same in each case, and it will be evident that such defects were most likely caused by a slight variation in the mode of conducting the acid hydrolysis process. At the present time, however, it seldom happens that abnormal cases of this kind are met with, a fact which is of the utmost importance in the finishing of the class of goods to which reference has been made.

On the other hand, however, goods which have been finished with thin-boiling starch are apt to develop a yellow colour on storing, especially if the finishing process has included a drying operation at a high temperature. This colour degradation is probably caused by the formation of traces of caramel, owing to the decomposition of reducing sugars which are usually present in the starch. Traces of acid are also occasionally present, and in this case, not only is the above defect rendered more prominent, but if ultramarine has been used for blueing purposes, the operation is wasted, inasmuch as the blue is more or less completely decolourised. Furthermore, such starches are far more liable to develop mildew than the ordinary starches. Experiments carried out by the author show that the latter defect is more pronounced in the case of converted starches made by the malt extract method.

It has been mentioned that the extent to which hydrolysis takes place in the manufacture of a thin-boiling starch is dependent upon the mode of procedure and the quantity of hydrolysing agent employed. In other words, by varying the amount or nature of the acid, or by drying for different periods of time or at different temperatures, starches of different degrees of solubility can be produced, and these yield pastes possessing different viscosities. If the process is carried to completion, dextrin and a variable quantity of its decomposition product, viz. :—dextrose, are produced. From these statements it will be evident that thin-boiling starches can be produced, which yield pastes with water of all degrees of consistency between that produced by thick-boiling starch, *i.e.*, ordinary starch on the one hand, and that produced by dextrin on the other. Ordinary laundry thin-boiling starch gives a thin paste when boiled with water at the rate of 1½-2 lbs. per gallon, while other varieties yield thin pastes with 4-6 lbs. per gallon.

Soluble Starch.—This is the name of a commercial substance which is similar to thin-boiling starch and may be prepared in

the same way, viz. :—By acid-hydrolysis, or by acting upon starch with oxidising agents or glycerine. It is in fact a partially hydrolysed starch, and from a consideration of its mode of preparation, as well as its properties, we may assume that it consists essentially of the intermediate product or products formed during the gradual conversion of starch into dextrin. Soluble starch occurs as a white powder, which is practically insoluble in cold water. It dissolves in hot water, however, yielding a thin paste, which differs from ordinary starch paste, in that it does not set to a jelly-like mass on cooling. Such a paste obviously possesses inferior stiffening properties, when compared with a paste of the same strength made from ordinary starch.

Soluble starch is often used in finishing soft goods, to which it imparts a high gloss on ironing, while at the same time the natural physical properties of the fibres suffer little or no degradation.

Soluble Starch Produced by Ferments.—Reference has already been made to the action of malt extract in converting starch into soluble derivatives (p. 51). It is well known that this action is induced by peculiar ferments termed enzymes, which are present in the malted grain. These appear to be definite chemical substances, but their nature and mode of action are not fully understood. A comparatively small amount of an enzyme is capable of effecting the conversion of an enormous amount of the fermenting material. The enzymes of malt are collectively known as *diastase*, but only a few of these appear to be starch-altering bodies. The chief chemical changes brought about by their action on starch, finally results in the production of maltose, soluble starch and dextrin being formed as primary and intermediate products respectively. Although malt-infusions have long been used by calico-printers for effecting the removal of starch from printed cotton goods with a minimum amount of friction, it is only during the last few years that they have found application in other branches of the textile industry, this development being primarily due to the introduction of malt preparations specially manufactured for such purposes.

The *modus operandi* in preparing a "soluble starch" finishing paste from ordinary starch with the aid of malt extract, is indicated by the following example:—Mix 10 lbs. of starch with 12-20 gallons of water; raise the temperature high enough to gelatinise the starch completely, and then cool to about 150° F.; at this stage add 2-4 oz. of malt extract, previously dissolved in a small amount of lukewarm water. Stir thoroughly until the mixture attains the desired consistency, then raise the tempera-

ture of the mass to boiling-point, and boil for a few minutes in order to arrest the action of the enzymes. Finally, a little soap, Japan wax, etc., may be added according to the "finish" required, while the addition of a small amount of an antiseptic such as carbolic acid, formalin, etc., is generally desirable.

Feculose.—When starch is treated with glacial acetic acid at a fairly high temperature, an interesting chemical change occurs, the product being known in commerce as *feculose*. The dry starch is mixed with about 12 per cent. of acid and heated in a closed vessel at a temperature above 100° C., for a few hours. Excess of acid is then recovered by distillation, and the starchy mass cooled, and subsequently washed in order to remove the last traces of free acid. The product so obtained is finally dried in a suitable stove.

In this reaction the starch cellulose apparently does not undergo hydrolysis into dextrin-like substances, but forms an ester or salt termed starch-cellulose-acetate. The product varies in composition according to the strength and proportion of acid employed, the length of time occupied, and the temperature which obtains in the operation. The stronger the acid and the longer the treatment, the greater is the amount of starch-cellulose converted into the ester.

Feculose resembles starch in appearance. When heated with water, however, a thin paste is obtained, which on drying in layers, yields translucent films. On this account it is very serviceable for finishing goods which require a clear glossy "finish."

Gum Tragasol.—This substance has been introduced for finishing purposes as a substitute for starch. It is a natural gum obtained from the prepared seeds of the locust bean, which latter constitutes the fruit of the carob tree, *Ceretonia siliqua*. The seeds are extremely hard and contain about 86 per cent. of gummy matter, which is extracted by heating them with water under pressure in specially constructed pans.

Gum tragasol is only moderately soluble in water, so that special precautions are necessary when mixing it with the latter in order to ensure the production of a homogeneous mass. One method of accomplishing this result, is to introduce the gum into a steam-jacketed pan provided with mechanical agitators, along with a moderate quantity of hot water. The mass is then thoroughly agitated and when quite smooth more water is added gradually as required. Prepared in this way, it will readily mix with the starches and fatty matters, but it cannot be used with borax. If the mucilage is dried in thin layers, almost transparent films are obtained which possess great pliability and

strength. It is of interest to note that chemical analysis has shown that the gum possesses the same percentage composition as starch, although it does not contain a trace of the latter. Its chemical formula, therefore, is $(C_6H_{10}O_5)n$.

Gum tragasol possesses excellent stiffening properties, and as it is practically transparent, it can be used with advantage for finishing articles which need to be treated in such a way as to preserve or enhance the natural lustre of the fibres.

According to Lamb and Farrell, (*Journ. Soc. Dyers and Colourists*, 1909, p. 79), table linen dressed with gum tragasol, can be passed through a ntultiple roller machine without sticking to the rollers.

The best results are obtained by employing a mixture of water 7 parts, and gum tragasol 1 part. This mixture is said to give the necessary degree of stiffness combined with a "clothy" feel not obtainable by the use of starch. The authors already referred to, have carried out a number of experiments with mixtures of tragasol, starch, china clay, Japan wax, etc., and find that when stiffness is of greater importance than pliability, the following proportions may be used, the quantities being given in percentages on the total weight of water employed:—

Water 100, tragasol 10 to 20 per cent., rice starch 0.25 to 2 per cent., china-clay 2 to 4 per cent., Japan wax 0.05 to 0.1 per cent.

The following mixture was found to be suitable for use on both decoudun and multiple roller machine:—

Water 100, tragasol 12.5, maize starch 0.25 to 0.5 per cent.

Tragasol was also found very useful in the dressing of muslin and other blouses, which need to possess a soft pliable "finish."

In finishing curtains tragasol is said to possess many advantages. It imparts good draping properties, and protects the threads from tendering, whereas it is well known that starch exerts a tendering action on delicate threads.

The following mixtures are recommended for a high-class curtain trade:—

Water 6-12 parts, tragasol 1 part.

This gives a beautiful result; where more stiffness is required the following is advocated:—

Water 100 parts, tragasol 15 parts, starch 1½ parts.

Or a cheaper dressing as follows:—

Water 100 parts, tragasol 10 parts, starch 2 parts, mineral white 3 parts.

Starch Preparations.—It has long been known that the addition of a small quantity of strong caustic soda solution to starch suspended in water causes it to swell up and become highly tenacious. At the same time the pasty mass becomes translucent and may be diluted with a considerable quantity of water, without losing its property of "setting" in the form of a jelly-like and more or less viscous paste.

Advantage is taken of this property of starch in the preparation of various so-called "finishes," which are sold under such names as "globuline," "crystal finish," "clear finish," etc., etc. They are prepared by modifying one or other of the starches with caustic soda solution, and afterwards neutralising the excess of alkali by means of a suitable acid. Example:—

"Clear Finish":—31-32 lbs. of starch, 12 gallons of cold water, 16 lbs. of caustic soda soltuion 42° Tw.

Introduce the starch into a suitable vessel provided with agitators and make into a paste with the water. Then add the caustic soda solution gradually with constant stirring, during a period of about 2-3 hours. Allow the mass to stand for a short time and then neutralise the excess of alkali by adding cold dilute sulphuric acid in small portions at a time, stirring continually. About 3 pints of acid, 168° Tw.,—previously diluted with about 1½ gallons of water and allowed to cool—will be required.

When the whole of the acid has been added, the mixture should be tested with litmus paper. If it is acid, a small quantity of ammonia is added from time to time with constant stirring until the litmus paper just turns blue. It is advisable to render the mass slightly acid, if, on first testing, it turns litmus blue, and then to render alkaline by the addition of ammonia. Finally the excess of the latter is neutralised by the addition of acetic acid.

Preparations of this kind are only used to a limited extent in conjunction with boiled starch. They impart a more lustrous appearance to the finished articles than untreated starch.

2.—GLOSSING MATERIALS.

The lustrous or glossy appearance which is frequently exhibited by a newly finished textile fabric is caused by the reflection of a greater or less proportion of the rays of light which fall upon its surface, so that the greater the amount of reflection the higher the lustre. If the surface on which the rays of light fall be rough, the greater portion of the incident light is scattered; consequently little or no lustre is exhibited by rough surfaces. On the other hand, if the surface be smooth, the greater proportion

of the light which falls upon it is reflected and the surface appears glossy.

It thus appears that the lustre exhibited by a fabric is entirely dependent upon the production of a smooth polished surface, and in order to achieve this object in the finishing of cotton and linen goods, it is necessary to impregnate the fibres and to fill up the interstices between warp and weft with a suitable substance, which under the subsequent influence of heat and in presence of moisture, is capable of developing properties that cause the impregnated fibres to become bound together into a coherent mass. The surfaces of a textile fabric treated in this way, may be rendered smooth and glossy by subjecting them to friction in presence of heat and traces of moisture, the degree of lustre produced being largely governed by the amount of friction employed. The chief substance used for filling up the interstices between warp and weft, as well as for penetrating the fibres and gumming the "down" of the threads, is starch, which not only acts as a stiffening material, but is also capable of developing a greater or less amount of lustre.

For the purpose of enhancing the inherent lustre-producing properties of starch, however, it is of the highest importance that it should be incorporated with other substances which assist in the production of a lustrous surface without the goods having to be subjected to an excessive amount of friction. With this object in view, a custom has arisen in the finishing industries, of adding substances of a waxy or soapy nature to the starch mixture.

By the action of heat in the subsequent ironing operation, the wax forms an exceedingly fine film on the surface of the material, which on further ironing may be caused to acquire a very high lustre.

Waxy substances which do not readily form emulsions cannot be used in the actual process of starching with raw starch, hence if such substances are used at all they are simply rubbed over the surfaces of the articles by hand during the ironing operation. In connection with the raw starch as well as the boiled starch processes, borax is commonly employed to assist in the production of lustre. It appears to modify the starch in such a way as to cause it to acquire increased lustre-producing qualities.

Borax forms the basis of a large number of so-called "glazes." White curd soap is also commonly used with raw starch to assist in the production of gloss, but when a high lustre is required it is the usual custom to employ one of the proprietary "glazes" on the market. Commercial "glazes" consist essentially of mixtures of Japan or other wax, soap, French chalk,

glycerine, etc. The composition of a few typical varieties is indicated by the examples given below:—

No. 1 Glaze:—

9 parts white curd soap.
2½ parts Japan wax.
87 parts water.

Boil until a smooth paste is obtained; then add

2¼ parts French chalk.
¾ part glycerine.

No. 2 Glaze:—

12 parts white curd soap.
67 parts water.

Boil as above, and add

20 parts French chalk.
1 part glycerine.

These are in the form of pastes. A dry glaze may be prepared by thoroughly mixing the following substances:—

7½ parts powdered Japan wax.
14½ ,, ,, starch.
3 ,, ,, gum arabic.
75 ,, ,, borax.

Japan Wax.—As its name implies, this substance is imported from Japan. It is obtained from the fruit of a tree belonging to the *Rhus* family. The raw wax is greenish in colour, but on exposure to sun and air becomes almost perfectly white. It consists chiefly of palmitin, and can thus be easily saponified, while its property of readily forming an emulsion on agitation with hot water, is of considerable importance in view of its use in the manufacture of laundry glazes, and various finishing pastes. Its melting point varies from about 123° to 128° F.

Beeswax.—This wax is of animal origin, being secreted by bees for the purpose of building the walls of the cells of their combs. In the raw state it possesses a yellow colour, but may be bleached by exposure to air and light, or by chemical means. Its melting point varies from about 139°-146° F. Beeswax can be saponified by heating with alkalies, but it finds only a limited use in finishing operations on account of its price.

3.—SOFTENING AGENTS.

When a mixture of ordinary starch and water is used for finishing textile fabrics the ultimate effect is often harsh and the goods lack pliability. At the same time a considerable amount of friction is set up during the mechanical operations involved.

In the majority of finishing processes, therefore, it is necessary to add to the finishing paste, a substance or substances which counteract the harsh effects produced by the use of starch alone.

Substances employed for this purpose are called softening materials, and they may be classified as (*a*), substances which partake of an oily or fatty nature, and (*b*), substances which possess the property of absorbing moisture from the atmosphere, *i.e.*, deliquescent materials.

It is well known that the use of a "softener" in finishing not only prevents the production of harsh effects, but in addition, the articles acquire a greater degree of "fulness" and pliability. The chief softening agents used in laundry work are glycerine and olein; either one or both of these substances being usually present in the trade "finishes" or "glazes" sold by drysalters. Soap and the waxes already mentioned also act as softening agents.

Glycerine.—This substance is a highly important softening agent, and is used to a great extent in the pure finishing of linen goods. It is obtained as a bye-product in the manufacture of soap, and is rarely adulterated. Glycerine readily absorbs moisture from the air, a property upon which its softening power principally depends; it mixes readily with most of the ingredients commonly used in finishing. Its chemical formula is $C_3H_5(OH)_3$ and the strength of the commercial article may be judged by means of the hydrometer and reference to the table given in the appendix.

Olein or **Soluble Oil.**—This product is employed to a considerable extent for softening purposes. It is prepared by acting upon castor oil with strong sulphuric acid. A good class oil may be obtained by proceeding as follows:—Introduce into a stoneware vessel 5½ gallons of castor oil and add during the course of about six hours, 9 pints of sulphuric acid 168° Tw.

The vessel should be provided with agitators and the mixture must be kept cool during the addition of the acid. After all the latter has been added, the mixture is allowed to stand for about 12 hours, and then run into a solution of common salt of about 10° Tw., contained in a wooden vessel. It is thoroughly mixed and allowed to stand. The olein rises to the top, and the acid salt solution below is removed by means of a suitable tap. The olein is next washed with more salt solution, the latter removed as before, and the former finally neutralised with weak caustic soda solution. It is preferable to make the olein just alkaline with caustic soda, then make slightly acid by the addition of acetic acid, and finally neutralise with ammonia.

In addition to the softening materials mentioned above, there are many other substances, such as tallow, different varieties of soap, various oils, etc., which are used in conjunction with starchy substances for finishing textiles, but in the laundry industry, it is neither desirable nor necessary that the substances used for finishing purposes should be changed from time to time, or that a large number of ingredients should be incorporated in the finishing mixtures. In general, it will be found that the simpler the ingredients used in making finishing mixtures, the better and more uniform will be the ultimate results.

4.—BLUEING MATERIALS.

Tinting Blues.—These are employed for the purpose of correcting the objectionable yellowish tint which is so often exhibited by newly bleached or re-washed white linen and cotton goods. They may be briefly classified as soluble and insoluble blues, according to their behaviour in presence of water. To the first class belong the ultramarine blues and smalts, while the second class includes the various blues derived from coal tar products; also indigo extract and laundry liquid blues.

Ultramarine Blue.—This substance is prepared by strongly heating a mixture of china-clay, sodium carbonate, and sulphur, in fire clay crucibles. The product obtained in this way, is characterised by a violet blue tint, and is to be preferred instead of the greenish blue variety prepared from a mixture of china-clay, sand, sodium sulphate, coal, and rosin.

The former is used on a very large scale in laundry work; it occurs in the form of an impalpable powder, insoluble in water. Ultramarine blue is unaffected by alkalies, but is very sensitive in presence of acids, and is readily decomposed even by such weak acids as acetic and oxalic. It is practically unaltered by the heat of the finishing irons, and is very fast to light, these properties being of the highest importance.

Smalts.—This blue consists of powdered blue glass, which owes its colour to the presence of cobalt. It possesses a fine violet-blue tint, and is fast to light, acids, alkalies, and heat. Owing to its expensive nature, however, and its comparatively high density it is not now used in the laundry.

Prussian Blue.—The term "Prussian blue" is used to indicate certain blue precipitates obtained by the action of iron salts on ferrocyanides. Their composition is more or less complex and varies to a greater or less extent.

Insoluble Prussian Blue.—This is the name given to the blue precipitate obtained when a solution of yellow prussiate of potash is added to a solution of ferric chloride. The precipitate is insoluble in water, but if the prussiate is in excess, a blue precipitate is obtained, which when freed from impurities is soluble in pure water. It is termed soluble Prussian blue. The former consists principally of ferric ferrocyanide, $Fe_43Fe(CN)_6$, while the latter is represented by $K_2Fe_22Fe(CN)_6$, *i.e.*, ferric potassium ferrocyanide.

Turnbull's Blue.—If solutions of ferrous chloride and red prussiate of potash are substituted for those mentioned in the last paragraph, a precipitate of Turnbull's blue or ferrous ferricyanide $(Fe_2)_34Fe(CN)_6$ is obtained.

None of the preceding ferrocyanide or ferricyanide compounds appears to be used separately for laundry work.

Liquid "Prussian" Blue.—The "Prussian" blue frequently sold as a liquid laundry blue consists essentially of a mixture in varying quantities of insoluble and soluble Prussian blues, and also Turnbull's blue, dissolved in oxalic acid solution.

It is usually prepared by simply adding powdered "Prussian" blue to a weak solution of oxalic acid. The following proportions may be used, viz. :—4 ozs. of the powdered blue, 1 oz. of oxalic acid, and one gallon of water.

The powdered "Prussian" blue or pigment used for the purpose occurs in commerce as a rich blue powder or as lumps, which exhibit a copper-like lustre. It is prepared by adding a solution of ferrous sulphate to a solution of yellow prussiate of potash, collecting the white precipitate which is formed and oxidising with nitric acid. "Prussian" blue is fast to light, and acids, and withstands a fairly high temperature, but it is more or less readily decolourised in presence of alkalies.

Indigo Extract or **Indigo Carmine.**—This blue is prepared by dissolving indigo in strong sulphuric acid and precipitating the product with salt to remove objectionable impurities. Finally, excess of acid is carefully neutralised by the addition of sodium carbonate. When well prepared it is quite neutral and easily soluble in water, in which latter state it is sometimes sold as a liquid blue. The tint is of a greenish-blue colour, and it is fast to acids and alkalies, but not very fast to light. Indigo carmine now finds only a very limited use in the laundry.

Coal-Tar Blues.—The tinting blues obtained indirectly from coal-tar are soluble in water, and in most cases possess a greater or less degree of affinity for the different fibres. Only those possessing a red or violet shade should be employed. The majority

are not very fast to light and they vary to a considerable extent in their behaviour towards acids, alkalies, and heat. Amongst those in use, may be mentioned the methyl violets, night blue, nile blue, acid violets, and even some of the direct blues and violets.

5.—WEIGHTING OR FILLING AGENTS.

It is the custom in many works to use weighting agents other than starch for the purpose of imparting a fuller and better appearance to certain classes of new articles such as low quality collars, cuffs, etc. One of the best known substances belonging to this class is *china clay*, $Al_2O_3.2SiO_2.2H_2O$, which—apart from its weighting properties—is used to a limited extent, as an addition to finishing pastes in order to minimise the tendency of starched goods from sticking to the hot rollers of certain types of multiple roller ironing machines. China clay or kaolin is a hydrated silicate of alumina, which is found in the earth's crust mixed with other impurites, from which it is separated by a levigation process. Its use in small and varying quantities as an addition to finishing pastes necessitates the exercise of great care in order to obtain a uniform mixture—and its presence on vegetable fibres is apt to induce a considerable amount of friction during the ironing operations. For most practical purposes in the laundry, china-clay is undesirable and unnecessary.

French Chalk or **Talc.**—$3MgO.4SiO_2.H_2O$.—This substance is the most important filling material used in laundry work. It generally forms one of the chief constituents of all proprietary "glazes," which are sent out in the form of pastes. French chalk occurs in commerce as a fine white powder with a characteristic greasy feel. When mixed with soap, starch, wax, etc., it forms an excellent medium for the purpose of "filling" the fibres of textile articles composed of cotton or linen. In laundry work, its use is confined to the "filling" of the surface fibres, as well as any interstices between the warp and weft threads. Owing to its extremely fine state of division, and its property of forming a perfectly homogeneous mass with water, it produces a surface on ironing which is characterised by a high degree of smoothness. Consequently, an excellent lustre, or glaze, can be readily developed on collars, cuffs, etc., with its aid. It should be noted, however, that its use in excessive quantities introduces washing difficulties when the goods are returned to the laundry. Only the best varieties should be used, as inferior brands are associated with various impurities such as clay, iron, and lime. The

following analyses of several commercial samples serve to show the variable nature of the substance obtained from different countries. (*Journ. Soc. Chem. Industry*, 1898, p. 64.):—

Country of Origin.	Austria.		France.		Italy.		Tyrol.		St. Gothard, Switzerland.	
Silicic acid	59·59	92·51	50·91	75·77	51·23	83.55	62·12	93·27	60·85	92·93
Magnesium oxide	32·92		24·86		33·32		31·15		32·08	
Iron-oxide, FeO	0·79	..	2·58	..	1·89	..	1·82	..	0 09	..
Calcium oxide	0·59	..	1·82	..	1·80	..	—		—	
Clay	1·76	..	13·19	..	7·08	..	—		1·71	..
Water, organic matter, &c.	3·79	..	6·64	..	5·46	..	4·73	..	4·95	..

6.—ANTISEPTICS.

The substances included under the term "antiseptics" act also as disinfectants, so that the two terms are merely indicative of the manner in which such substances are employed. An antiseptic is added to the medium in which bacteria are capable of multiplying under suitable conditions. Consequently its action is a continuous one provided that it is non-volatile, whereas a disinfectant is employed when it is necessary to destroy bacteria which have already multiplied to a greater or less extent, the destructive agent acting only for a comparatively short time. Among the many substances which act as antiseptics may be mentioned, carbolic acid, zinc chloride, salicyclic acid, mercuric chloride, formalin, boric acid, and borax. Of these, only borax is used to any great extent in the laundry industry, and even this substance merely acts as a mild antiseptic.

Powerful antiseptics are rarely required, because, as a general rule, domestic goods are not exposed under conditions which favour the growth of mildew. Goods for export such as embroidered bed-spreads, etc., which are usually finished in trade laundries have been known, however, to develop mildew on many occasions even in presence of borax, but such defects appear to be induced by insufficient care in the choice of the finishing materials, or by the mode of carrying on the finishing process.

An account of borax and its other uses in laundry work has already been given in the preceding pages. About ½-1 per cent. is considered sufficient to prevent the development of mildew on goods finished with ordinary starch.

Boric Acid, H_3BO_3.—This product occurs naturally in the volcanic districts of Tuscany. It is erupted from the earth's crust in jets of steam, the condensation product being collected in natural basins. Subsequently, concentration causes the acid to crystallise out. Boric acid is of considerable service when high quality white goods need to be treated with an antiseptic dressing. It is not very soluble, however, although it readily mixes with most of the substances used in finishing.

Carbolic Acid or **Phenol**, C_6H_5OH.—This substance is one of the products of the distillation of coal-tar. The crude acid is obtained by adding caustic soda to the distillate passing over between 150°-200° C., and the product, which is termed sodium phenate, separated from other oily substances not affected by the caustic soda. Sulphuric acid is then added in slight excess, and the liberated phenol subsequently purified by re-distillation. When pure, carbolic acid occurs in the form of colourless, needle-shaped crystals, which possess a peculiar smell. It has a powerful caustic action on the skin, causing severe burns, and dissolves readily in organic solvents, and in hot water, but is only slightly slouble (1 part in 15), in cold water. Carbolic acid is a very powerful antiseptic, but its use in this respect is limited, chiefly on account of its odour, which is readily detected even when minute quantities are used. It is extremely valuable, however, for disinfecting purposes.

Formaldehyde or **Formalin**, HCHO.—Formaldehyde usually occurs in commerce in the form of a colourless liquid termed formalin—which possesses a penetrating and suffocating odour. The commercial article consists essentially of a 40 per cent. aqueous solution of formaldehyde, which is prepared by passing ordinary air mixed with the vapour of methyl-alcohol over a heated spiral of copper or platinum, and condensing the gaseous product in water. It is used on a fairly extensive scale, both as a disinfectant and antiseptic, although it is more suitable as a disinfectant only, on account of its volatile nature.

Mercuric Chloride, $HgCl_2$.—This is sent out in the form of a transparent, crystalline substance, soluble in water. It is very poisonous, and exerts a powerful destructive action upon those low organisms which play such an important part in the decomposition of starch, flour, and other organic substances. Its properties in this respect, however, are not very widely recognised, owing to its high price, and its property of forming decomposition products with many of the substances employed in finishing.

Permanganate of potash is commonly employed as a disinfectant. Its preparation and properties have already been described in a previous chapter.

Salicylic acid, $C_6H_4\begin{cases}OH\\COOH,\end{cases}$ is orthohydroxy benzoic acid, and is prepared by distilling sodium phenate—obtained by neutralising caustic soda with carbolic acid—in an atmosphere of carbon dioxide, under pressure, whereby volatile impurities are removed, and the sodium salt of salicyclic acid together with excess of alkali left in the retort. On treating the residue with a mineral acid, salicylic acid is precipitated, and may be purified by re-crystallisation from hot water. The reaction which occurs is of considerable interest, in that it depends upon what is termed intramolecular change, the compound, $C_6H_5OCOONa$, first formed by the action of CO_2 under pressure on phenol, changing directly into sodium salicylate $C_6H_4\begin{cases}OH\\COONa,\end{cases}$ when heated at a temperature of 120-140°C., under like conditions.

Salicyclic acid occurs as a white crystalline compound, sparingly soluble in both cold and hot water, but readily soluble in various organic solvents. Like phenol, it gives an intense violet colouration with ferric salts.

It is an important antiseptic, being sometimes used as a substitute for phenol. Unlike the latter, however, the pure substance is devoid of smell. For laundered goods intended for export, salicyclic acid undoubtedly constitutes an excellent medium for the prevention of mildew.

Zinc Chloride, $ZnCl_2$.—This is manufactured by dissolving sheet zinc in hydrochloric acid contained in suitable vessels, and subsequently removing the impurities, *e.g.*, iron and manganese, by neutralising the solution with caustic soda, heating to about 45-50° C., and adding bleaching powder solution. The iron and maganese are thus oxidised, and precipitated, and the clear solution may be filtered off, and evaporated to dryness. Zinc chloride occurs as a white mass, which is very deliquescent. It is easily soluble in water and is chiefly used in the sizing of cotton goods as an antiseptic and deliquescent. The commercial article is usually sold in liquid form indicating from about 90°-104° Tw.

SECTION V.—MISCELLANEOUS SUBSTANCES.

Under this heading is given a brief description of those substances which are occasionally used in the laundry for special purposes, such as the removal of stains of a greasy nature; hand cleaning small and delicate articles; fireproofing, etc.

Solvents for Grease, Wax, etc.—These are of organic origin and are employed for removing oil, fat, wax, and paint stains which resist the usual washing operations. The majority are highly inflammable, volatile liquids, so that their use necessitates the exercise of the greatest possible care. Special articles of a frail nature or those which might be affected injuriously in presence of water and soap, are sometimes cleansed by agitation in a non-inflammable organic solvent, but as a general rule, such goods are best dealt with by the dry-cleaner.

Benzol or **Benzene**, C_6H_6.—This substance is one of the products of the distillation of coal-tar, and is obtained as a colourless, inflammable liquid with a peculiar smell; it is lighter than water, in which it is insoluble. Benzene should not be confounded with the benzine or benzoline used in dry-cleaning. The commercial article consists essentially of a mixture of about 70 per cent. benzene and 20-30 per cent. toluene.

Benzene should be kept and used in a cool place, and on no account should it be employed in the neighbourhood of a naked light. It finds a limited application in the laundry for the removal of stains caused by the presence of certain unsaponifiable oils and fats.

Benzine, Petroleum Benzine, or **Benzoline.**—Petroleum benzine is one of the products of the distillation of crude petroleum. It is produced on an enormous scale in America, and to a considerable extent in Sumatra, Russia, Borneo, etc. Benzine is lighter than water, in which it is insoluble; it consists of a number of hydrocarbons having different boiling points, so that if the liquid is distilled varying quantities will be collected at different temperatures. The benzine now largely used by dry cleaners has a specific gravity of about 0.780, and is rarely adulterated. It is very inflammable, giving off an explosive vapour at the ordinary temperature; consequently, special precautions have to be taken in establishments in which large quantities are used, in order to guard against fire.

The vapour of benzine possesses toxic properties and efficient ventilation must be provided in the workrooms when it is used in quantity.

It is only employed in the laundry to a limited extent for the removal of grease stains, and may be used alone or in conjunction with benzine soap. The use of benzine as a cleansing agent in dry-cleaning depends upon the fact that a large proportion of the dirt on textile materials is intimately associated with greasy matter. Hence, when such articles are immersed in benzine, the grease dissolves, and the dirt is then removed by the agitation to which the goods are subjected during the treatment.

Chloroform, $CHCl_3$.—Chloroform exerts a more powerful action upon various grease, wax, and other stains than petroleum benzine or other organic solvents, and, in consequence, it is frequently used for removing stains which offer considerable resistance towards the action of the usual agents. It is manufactured by boiling a mixture of alchohol or acetone with bleaching powder and water, whereby it is ultimately obtained in the form of a heavy, colourless, and non-inflammable liquid with an ethereal smell. Its specific gravity is 1.525, and boiling point 61°-62° C. The commercial article is cheaper than the purified product used for anæsthetic purposes, but it is quite as serviceable for removing stains. Chloroform,—as well as other organic solvents of rubber—should not be used, of course, for the treatment of rubber or rubber-coated articles.

Carbon tetrachloride, CCl_4, is prepared by passing a mixture of chlorine and the vapour of carbon disulphide through a heated tube, or by the action of the latter compound on sulphur chloride, a little metallic iron being added to the mixture in the latter case as a "chlorine carrier." Carbon tetrachloride is a heavy colourless liquid with a smell almost like chloroform. It has a specific gravity of about 1.63, and boils at 76-77° C. It readily dissolves many kinds of greasy matter, and, like chloroform, possesses toxic properties. When heated with steam, it undergoes decomposition, and the change is liable to be accompanied by an explosion. One of the products formed is hydrochloric acid.

Non-Inflammable Solvents.—Practically all the organic solvents mentioned above are either very inflammable, explosive, or decompose with great violence under suitable conditions, so that their use in textile and other processes is accompanied by considerable danger. Unfortunately the question of cost has hitherto precluded the general use of suitable non-inflammable substitutes, although it may be remarked that some of the chlorine derivatives of ethane and ethylene are now being utilised in many laundries and dry-cleaning establishments—principally on the continent—for the local treat-

ment of fat stains, etc., instead of the usual solvents. These substances differ from benzine, in that they are single compounds; hence, they possess definite boiling points. They are non-inflammable, non-combustible, and non-explosive, and exert a powerful solvent action on fats, waxes, resins, etc. The best known compounds are characterised by great stability, and their boiling points are of wide range. Among the more important derivatives manufactured on a commercial scale are tetrachloro- and pentachloro-ethane, and dichloro-, trichloro-, and tetrachloro-ethylene. These have been examined by Clément and Rivière, (*Journ. Soc. Chem. Industry*, 1910, p. 718), and the results obtained are included in the table given below:—

Name.	Formula.	B.P.	Sp. Gr.	Anæsthetic Properties	Solubility in Water.
sym.-Tetrachloroethane..	$C_2H_2Cl_4$	147°C.	1·6	Very slight	Slight
Pentachloroethane	$CHCl_5$	159°C.	1·7	Ditto	Ditto
sym.-Dichloroethylene ..	$C_2H_2Cl_2$	55°C.	1·25	—	Ditto
Trichloroethylene	C_2HCl_3	88°C.	1·47	Pronounced	Ditto
Tetrachloroethylene	C_2Cl_4	121°C.	1·62	Ditto	Ditto

Name.	Volatility.	Effect of Strong Alkalies.	Other Properties.	Uses.
sym.-Tetrachloroethane..	Low.	Partially decomposes.	Attacks iron and copper in presence of moisture.	Solvent for fats, oils, resins, &c.
Pentachloroethane	Ditto	Ditto	—	Ditto
sym.-Dichloroethylene ..	—	—	No action on iron & copper.	Substitute for ether.
Trichloroethylene..	—	None.	—	Satisfactory substitute for carbon tetrachloride & benzol.
Tetrachloroethylene	—	—	—	Solvent for fats. Domestic cleansing purposes.

The most important compounds for textile purposes appear to be trichloroethylene and tetrachloroethane. The former is sold in this country under the name of "Westrosol" and the latter "Westron."

Turpentine, $C_{10}H_{16}$, is frequently employed in the laundry for removing paint and varnish stains, upon which it exerts a power-

ful solvent action. In some cases, it is added to the starch mixture used in finishing. Turpentine or oil of turpentine is manufactured by distilling the sap of pine trees in a current of steam, the residue in the retort being known as resin or colophony. It is a colourless, inflammable liquid, with a peculiar and not unpleasant smell; its specific gravity is 0.86, and boiling point 158°-160° C., but as it is a mixture of compounds, these physical properties vary considerably according to the species of pine from which it has been obtained. On exposure to air, oxidation takes place, and the liquid gradually darkens, becomes more and more viscous, and finally forms a resinous mass, which is more or less coloured according to the purity of the original turpentine.

Turpentine is almost insoluble in water, but mixes with most organic liquids, and is largely used in the manufacture of paints and varnishes, and indirectly as a disinfectant.

Fireproofing Substances.—The employment of fireproofing materials in modern laundry work has not yet made much progress, although there is undoubtedly plenty of scope in this direction, especially as regards the fireproofing of curtains, flannelette goods, and other articles of a highly inflammable nature.

A considerable number of patent specifications relating to fireproofing mixtures and processes suitable for textiles, have been published during recent years, but most of the substances advocated have long been known to possess fire-resisting properties.

Two distinct methods of reducing the inflammability of fibrous materials are in use; the first of these has for its object, the deposition of an insoluble metallic oxide, or salt, on the fibres, while in the second case, the fireproof effect is achieved by impregnation with a solution of a suitable salt, and subsequently drying without washing.

The reaction involved in fireproofing according to the first method is known as double decomposition. Thus, if fibres be first treated with a solution of alum and then passed through a weak alkaline bath, double decomposition occurs, and aluminium hydrate is precipitated, as :—

$$Al_2(SO_4)_3.K_2SO_4 + 6NH_4OH = Al_2(OH)_6 + 3(NH_4)_2SO_4 + K_2SO_4.$$

In this process, it is essential, as a general rule, to use a salt of a metal which yields a colourless hydrate. Instead of the hydrate, however, the phosphate, or a mixture of hydrate and phosphate, *i.e.*, a basic phosphate, may be precipitated, by pass-

ing the alum impregnated material through a solution of sodium phosphate, or alkaline sodium phosphate respectively. Again, double salts may be precipitated, as indicated in the following example:—Pass the material successively through solutions of alum, sodium phosphate, magnesium sulphate, and sodium phosphate. Repetition of these operations, as well as intermediate squeezing operations, are usually necessary in order to obtain satisfactory results.

Older methods recommended or patented for producing precipitates possessing fire-resisting properties, are dependent on double decomposition between sodium silicate and certain other salts, such as magnesium sulphate, calcium chloride, etc., whereby insoluble silicates are obtained, while a method analogous to that sometimes adopted in mordanting cotton with stannate of soda is also employed. In carrying out the latter process, the goods are simply passed through a solution of sodium stannate (Na_2SnO_3) about 4°-10° Tw., and then through a weak mineral acid, followed by washing in water rendered slightly alkaline with ammonia. Stannic hydrate is precipitated on the fibre and is ultimately converted into the oxide (SnO_2) on drying.

The above processes are utilised in the production of "permanent fireproof finishes," *i.e.*, finished effects capable of withstanding long continued washing without losing their fireproof nature, provided, of course, that the operation has been properly conducted.

Processes of this kind, however, find little application in the laundry industry, since they require very careful supervision, and are considered to be too expensive for general work, while in the case of goods which need to be finished with starch, it is necessary to first carry out the fireproofing operation and then dry the goods, after which the actual starching operation takes place.

The processes most suitable for laundry work are those in which the goods are simply impregnated with a solution containing one or more fireproof substances, followed by drying without washing, so that each fibre retains a greater or less amount of the substance used. The efficiency of a process of this kind is governed by the nature of the substance or substances used, and the amount present on the fibres. Too great a quantity may exert a deteriorating influence on the material treated, while too small an amount has little effect on the combustible properties of the material.

Among the more important materials employed are the phosphate and chloride of ammonia; ordinary alum; borax, and the phosphate and tungstate of soda. Any of these may be used alone, but better results are usually obtained by employing mixtures. Of course, mixtures of salts which undergo double decomposition, *e.g.*, alum and a phosphate, should not be used.

The behaviour of different compounds is best ascertained by actual experiment, while information concerning the minimum amount required to give a satisfactory result is obtained in the same way. If the goods need to be finished with starch, the fire-resisting substance may be added to the starch mucilage and the two operations combined. A short account of some of the compounds already enumerated is given below:—

Sodium phosphate, $Na_2HPO_4.12H_2O$, is prepared from superphosphate of lime (acid calcium phosphate),—obtained by the action of sulphuric acid on bones—by neutralising the acid liquid with sodium carbonate, and then concentrating, until crystals having the composition $Na_2HPO_4.12H_2O$ are deposited. Commercial sodium phosphate usually contains sodium sulphate as an impurity. The crystals effloresce on exposure to air. On heating to about 300° C., a molecule of water is lost and sodium pyrophosphate formed. Sodium phosphate is soluble in about 35 parts of cold, or 1 part hot water. It possesses excellent fire-resisting properties, but is too expensive to use alone.

Ammonium phosphate, $(NH_4)_2HPO_4$, is made by a process similar to that given above. It is more expensive than the corresponding sodium salt, and on this account it only finds a limited employment.

Double phosphates such as microcosmic salt, NH_4NaHPO_4, are sometimes used.

Ammonium Chloride or *Sal-Ammoniac*, NH_4Cl.—Ammonium chloride is manufactured by neutralising the crude ammoniacal liquor of the gas works with hydrochloric acid, separating precipitated sulphur, and subsequently concentrating the solution in a wooden tank fitted with a steam coil, until it is strong enough to deposit crystals. The latter are partially purified by dissolving them in water and filtering the solution through animal charcoal. The crystals ultimately obtained constitute the muriate of ammonia of commerce.

Ammonium chloride is also made by double decomposition between crude ammonium sulphate and a suitable chloride, *e.g.*, sodium, calcium, or barium chloride.

It occurs in commerce in the form of crystals, and as a hard fibrous mass. Its aqueous solution dissociates on heating, with the result that ammonia gas is evolved and the solution rendered acid. The solid article readily volatilises when heated.

Sodium tungstate, Na_2WO_4, is prepared indirectly from the mineral calcium tungstate. The crude ore is first treated with nitric acid, whereby the trioxide, WO_3, is precipitated in the form of a yellowish powder. This compound dissolves in caustic alkalies, yielding the corresponding salts; thus, the best known salt, Na_2WO_3, is obtained by dissolving the trioxide in caustic soda. Sodium tungstate occurs in commerce in the form of a heavy, dull white powder. It dissolves in water, yielding an alkaline solution, and is considered to be one of the best fireproofing agents yet discovered.

CHAPTER III.

Water.

It has long been recognised in the laundry industry, that a good supply of suitable water for washing purposes, and for steam raising, is of the utmost importance. Unfortunately, however, most natural waters contain various impurities which are more or less objectionable according to their nature and amount. Suspended impurities can be readily removed by filtration, but impurities in solution can only be removed by chemical means.

Rivers and streams are the chief sources of water for laundry purposes; spring and well waters are used when there are no available streams or when the latter are contaminated with refuse water from various sources.

Rain water is the purest form of natural water, being in fact a naturally distilled water. It cannot be collected in any great quantity, however, before it has mingled with water from other sources and come into contact with the earth's crust. A portion of the water which falls as rain, drains over the earth's surface, ultimately finding its way into the nearest stream; another portion sinks into the ground and may travel underground for miles until it reappears as a spring. On the other hand it may travel underneath impervious strata and form large continuous reservoirs in the subterranean passages of the earth's crust; consequently, if the overlying strata be bored, the pressure of the water at higher levels enables a continual supply to be maintained. Artesian wells are obtained in this manner.

Spring and well waters contain large amounts of dissolved matter, chiefly salts of calcium and magnesium. River water consists principally of a mixture of spring and rain water which has drained over the surface of the earth; such water frequently contains refuse water discharged from works situated near the source as well as a fair amount of suspended matter and dissolved impurities.

Water containing salts of calcium and magnesium in solution is known as "hard" water, because it yields a lather with soap only with difficulty. This property of "hardness" is distinguished as temporary and permanent hardness according to the nature of the salts in solution. Temporary hardness is chiefly caused by the presence of the carbonates of calcium and magnesium. These are practically insoluble in pure water, but dis-

solve slowly in water containing carbon dioxide with the formation of so-called bicarbonates, as:—

$$CaCO_3 + CO_2 + H_2O = CaH_2(CO_3)_2.$$

Calcium carbonate + carbon dioxide + water = calcium bicarbonate.

Spring and well waters invariably contain considerable quantities of carbon dioxide, which is acquired during their passage over the earth's crust; hence, such waters exert a powerful solvent action on the limestone and magnesium rocks with which they come into contact. Other common constituents are the sulphates of calcium and magnesium, the former being soluble to the extent of about 150 grains per gallon.

The presence of *calcium salts* is indicated by the formation of a white precipitate on the addition of a few drops of ammonium chloride and ammonium oxalate to a small quantity of the water.

Magnesium salts are detected as follows:—Remove all traces of calcium by proceeding as above and then boiling the liquid for a minute or two in order to facilitate the deposition of calcium oxalate. Filter, and add a little ammonia and sodium phosphate to the clear filtrate. Shake vigorously and allow to stand for a short time, when the production of a white crystalline precipitate indicates the presence of magnesium.

Bicarbonates yield a white precipitate on the addition of clear lime water. Free "*carbonic acid*" reacts in the same way.

Sulphates are indicated by the formation of a fine white precipitate on adding a few drops of hydrochloric acid and barium chloride.

Chlorides give a white curdy precipitate on the addition of nitric acid and silver nitrate.

On boiling a water containing calcium bicarbonate, carbon dioxide is evolved and calcium carbonate precipitated. This reaction has given rise to the term "temporary hardness," inasmuch as such hardness is caused by the presence of salts which are thrown out of solution on boiling, as:—

$$CaH_2(CO_3)_2 = CaCO_3 + CO_2 + H_2O$$

If the sulphates or chlorides of calcium or magnesium are present, however, the water is said to possess permanent hardness, *i.e.*, hardness that cannot be diminished by boiling.

The so-called soap-destroying power of hard water is due to the formation of "soaps" which are insoluble in water. Under ordinary conditions, these float on the water in the form of a greasy scum, but in laundry washing processes in which hard water is used continuously, they ultimately collect as a thick greasy mass on the interior of the washing machine, and may give rise to serious defects.

The chemical action which results in the production of insoluble "soaps" when soap is brought into contact with hard water is an example of double decomposition, and may be represented by means of the following equations, in which soap is regarded as the sodium salt of stearic acid:—

$2C_{17}H_{35}.COONa + CaCO_3.CO_2.H_2O = (C_{17}H_{35}.COO)_2Ca + 2NaHCO_3.$
Soap or sodium stearate + calcium bicarbonate = calcium stearate (insoluble lime "soap") + sodium bicarbonate.

$2C_{17}H_{35}.COONa + MgSO_4 = (C_{17}H_{35}.COO)_2Mg + Na_2SO_4.$
Sodium stearate + magnesium sulphate = magnesium stearate + sodium sulphate.

With the exception of sodium and potassium, most metals yield "soaps" insoluble in water, so that if a water contains a salt of a metal capable of yielding a "soap" of this nature, and such water be used for washing purposes in conjunction with ordinary soap, double decomposition takes place, with the formation of an insoluble "soap" and a salt of the metal originally combined with the fatty acid constituent of the ordinary soap, as represented by the above equations. This action continues until the whole of the metallic salt in the water has been decomposed; hence, the greater the amount of calcium and magnesium salts in solution, the greater the amount of soap required to effect their decomposition, so that soap used in this way is frequently said to have been destroyed.

The characteristic behaviour of soap in presence of the above mentioned salts has given rise to a well known method for the determination of the hardness of water. It is based on the fact that a permanent lather cannot be obtained until the whole of the calcium and magnesium salts in solution have been decomposed. Therefore, if we make a standard solution of soap, and then find the number of cubic centimetres required to produce a permanent lather with a definite volume of hard water, we have a measure of the approximate amount of calcium and magnesium salts in solution. This test is by no means a reliable one, as it is readily influenced by the presence of alkalies or acids, and in other ways. It still finds considerable use, however, since it is comparatively simple and can be carried out rapidly. The results are expressed either as degrees of hardness, grains of chalk per gallon, or parts in 100,000.

Determination of the Hardness of Water.—A standard soap solution is made by dissolving 10 grms. of a pure neutral curd soap in one litre of 80 per cent. alcohol. The value of this solution—in terms of calcium carbonate—is then ascertained by running it from a burette into a known volume of standard hard

water, *i.e.*, a water containing a known weight of calcium carbonate or its equivalent, until it yields a lather which retains an unbroken surface at the end of a few minutes. The standard hard water is prepared by dissolving 1.11 grms. of pure anhydrous calcium chloride, (equivalent to one grm. of calcium carbonate), in one litre of pure water, so that 1 c.c. contains a quantity of calcium chloride equivalent to 0.001 grm. of calcium carbonate. The method of standardising the soap solution is carried out as follows:—10 c.cs. of the standard hard water, (containing the equivalent of 10 milligrams of calcium carbonate), are made up to 70 c.cs. with pure water, and introduced into a 10 oz. stoppered bottle or flask. The soap solution is then added from a burette about 1 c.c. at a time and the contents of the vessel violently agitated after each addition until a lather is produced which remains unbroken at the end of about five minutes. If the soap solution is of the correct strength, 11 c.cs. will be required to produce an unbroken lather; 1 c.c. of the soap solution is deducted from the volume required, because it is found that about 1 c.c. of the solution is required in order to produce a lather with 70 c.cs. of pure water. If more than 11 c.cs. of soap solution is required, the solution is too weak and must be strengthened by the addition of more soap; on the other hand, if less than 11 c.cs. is required, the solution is too strong and must be made up to the proper strength by the addition of alcohol, so that finally 1 c.c. corresponds to 1 milligram of calcium carbonate.

The volume of hard water taken, viz., 10 c.cs., is made up to 70 c.cs. with pure water in order that the number of c.cs. of standard soap solution required, may be expressed as the number of milligrams of calcium carbonate in 70,000 milligrams of water, *i.e.*, parts in 70,000; hence, as there are 70,000 grains in one gallon, the result obtained may be directly expressed in grains of calcium carbonate per gallon.

Estimation of Total Hardness.—The total hardness of a water is found by titrating 70 c.cs. of the water with standard soap solution until an unbroken lather is obtained. The number of c.cs. of soap solution required minus one, indicates the total hardness in degrees or grains of calcium carbonate per gallon. If 100 c.cs. of water be taken instead of 70, the result is expressed as parts of calcium carbonate in 100,000 parts of water.

Permanent Hardness.—This is determined by boiling 70 c.cs. of water for some time, so that the carbon dioxide which holds the carbonates of calcium and magnesium in solution is expelled and the carbonates precipitated. After cooling, the water is made up to 70 c.cs. with pure water, filtered, and titrated with soap

solution as before, the number of c.cs. required minus one, representing the permanent hardness.

Temporary Hardness.—The degree of temporary hardness is obtained by subtracting the number which represents the permanent hardness from the number representing the total hardness.

Water containing Iron.—Salts of iron—usually the bicarbonate and sulphate—are frequently met with in natural waters. The presence of sulphate of iron is due to atmospheric oxidation of iron pyrites occurring in the earth's crust, with the ultimate formation of ferric oxide (Fe_2O_3), and free H_2SO_4. If the carbonates of calcium and magnesium are also present, double decomposition takes place, resulting in the evolution of carbon dioxide and the formation of the corresponding sulphate. Consequently the amount of free acid is reduced and temporary hardness converted into permanent hardness, as :—

$$H_2SO_4 + CaH_2(CO_3)_2 = CaSO_4 + 2CO_2 + 2H_2O.$$

Water containing iron is very objectionable for any purpose which involves the treatment of white textile articles, because it not only imparts a yellowish tinge to the goods, but complex compounds of iron may be formed during the boiling processes, and these ultimately give rise to stains which can be removed only with great difficulty.

Detection of Iron.—About 100 c.cs. of the water to be examined are rendered alkaline by the addition of pure sodium carbonate and evaporated to a small bulk. A few c.cs. of dilute pure hydrochloric acid and a crystal of chlorate of potash are then added. The acid liquid is boiled and cooled, and a few drops of a solution of potassium ferrocyanide added. If a blue precipitate or colouration is produced, the water contains iron.

Purification of Water.—Since the nature and amount of the impurities in natural waters vary to a considerable extent, it is frequently desirable to effect some means of purification. Water containing much solid matter of a calcareous or similar nature and intended for use in conjunction with soap, or for steam raising purposes, is objectionable for the following reasons :—

1. A greater or less amount of soap is decomposed and wasted; it has been calculated that for each degree of hardness every 1,000 gallons of water renders useless 1½ lbs. of soap.

2. Sticky insoluble soaps are formed, and these frequently give rise to stains which are very difficult to eradicate.

3. The use of hard water for steam raising usually results in the production of boiler scale. The latter is a bad conductor of heat; hence, a waste of fuel occurs, while the plates are gradually weakened by unequal heating and by the high temperature at-

tained. The following table represents the approximate loss of heating power due to the presence of scale of varying thicknesses :—

Thickness of Scale	in. $\frac{1}{64}$	in. $\frac{1}{32}$	in. $\frac{1}{16}$	in. $\frac{1}{8}$	in. $\frac{3}{16}$	in. $\frac{1}{4}$	in. $\frac{3}{8}$	in. $\frac{1}{2}$
Loss of Heating Power...	2%	4%	9%	18%	27%	38%	48%	60%

As stated in a preceding paragraph, the carbonates of calcium and magnesium which are held in solution in water by dissolved carbon dioxide, are precipitated on boiling the water, owing to the escape of the gas. In the case of water used for steam raising, the precipitated carbonates accumulate on the boiler plates in the form of a loose powdery mass termed boiler mud. If calcium sulphate is also present in the water, the latter ultimately reaches a point of concentration at which no more of the former will dissolve, and further evaporation results in a portion being thrown out of solution. The calcium sulphate thus deposited becomes incorporated with the precipitated carbonates and the mass bakes on to the boiler plates, yielding an exceedingly hard scale.

Suspended Impurities.—Water containing suspended matter may be readily purified by filtration through sand or other suitable material.

Dissolved Impurities.—The chief dissolved impurities to be removed are the bicarbonates and sulphates of calcium and magnesium. The former are decomposed and precipitated on boiling the water or by the addition of a suitable reagent. The first method is inapplicable on a large scale, since, with coal at ten shillings per ton, the cost of raising 1,000 gallons of water to 100° C., is about one shilling. Consequently, recourse must be had to the second method.

The reagent generally employed is lime water, or milk of lime, which was first suggested by Dr. Clark, of Edinburgh. When lime water is added to water containing calcium bicarbonate, it interacts with the carbon dioxide, yielding insoluble calcium carbonate, while the calcium carbonate originally held in solution by means of the gas is precipitated at the same time, as :—

$$\begin{matrix}\{H_2O.CO_2 \\ \{CaCO_3\end{matrix} + Ca(OH)_2 = 2CaCO_3 + 2H_2O$$

Solution of CO_2 in water holding calcium carbonate in solution (Calcium bicarbonate). + lime water or calcium hydrate = calcium carbonate + water.

Temporary hardness caused by the presence of magnesium bicarbonate may be removed in the same way, or caustic soda may be used instead of lime water :—

$$MgCO_3.H_2O.CO_2 + 4NaOH = Mg(OH)_2 + 2Na_2CO_3 + 2H_2O.$$

In order to remove the salts which produce permanent hardness, it is the general practice to add (*a*), a solution of caustic soda, or (*b*), a mixture of lime water and sodium carbonate. Caustic soda does not yield a precipitate with a solution of calcium sulphate, but if it is added to a water containing both bicarbonate and sulphate, a greater or less amount of the latter is precipitated as calcium carbonate. This reaction depends firstly upon the formation of sodium carbonate by the action of caustic soda on the carbon dioxide in the water, as :—

$$CaCO_3.H_2O.CO_2 + 2NaOH = CaCO_3 + Na_2CO_3 + 2H_2O.$$

In the second place, the sodium carbonate thus formed reacts with calcium sulphate—

$$Na_2CO_3 + CaSO_4 = CaCO_3 + Na_2SO_4.$$

It is evident, therefore, that the efficiency of caustic soda as a water softening agent is influenced by the presence or absence of carbon dioxide in the water to be treated.

In most cases, a mixture of lime water or milk of lime and sodium carbonate is used for softening purposes ; a greater amount of the carbonate than is required to convert the lime completely into caustic soda is used when the permanent hardness is high. Magnesium salts are precipitated either as carbonate or hydrate according to the reagent employed, but as the hydrate is less soluble than the carbonate, it is customary to soften with lime water or caustic soda.

From a consideration of the foregoing remarks, it is apparent that the purification of water by chemical means, is dependent upon the readiness with which the impurities can be converted into compounds practically insoluble in water. Before this method can be adopted on a commercial scale, however, means must be provided for the rapid and efficient removal of precipitated matter. This is accomplished more or less completely by settling, or filtering, or both combined, and the whole process, viz :—The addition of the necessary chemicals and the removal of solid matter held in suspension, is carried on in specially constructed machines known as "water softeners." Many of these machines are automatic in action and very compact; they are to be preferred where space is limited. On the other hand, where plenty of space is available, a machine that possesses a comparatively large area

for settling and filtering purposes gives highly efficient results. It is impossible in a work of this nature to discuss the merits and demerits of the numerous appliances available, so that a description of only one or two typical machines which are known to give satisfactory results will be given.

William Boby's "Simplex" Water Softener.—This plant is a representative of the class, to which all machines working on the continuous system belong. It has been specially designed with a view to simplicity in working, while its general construction is such, that it can be easily understood by the ordinary attendant.

The machine is built in various forms, of which the most suitable for laundries are shown in the diagrams given below.

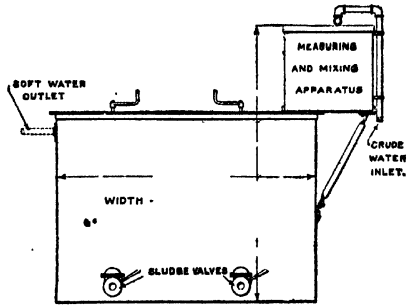


FIG. 10. "SIMPLEX" WATER SOFTENER WITHOUT STORAGE CHAMBER.

Fig. 10 illustrates a machine suitable for delivering softened water into a separate storage tank; the second type, (Fig. 11), is

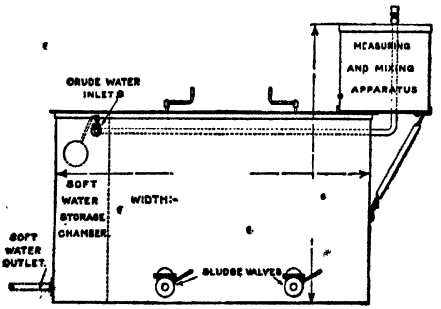


FIG 11. "SIMPLEX" MACHINE WITH SELF-CONTAINED STORAGE TANK.

provided with a self-contained storage chamber, and the third, (Fig. 12), is suitable for delivering water from the ground level into an elevated storage tank.

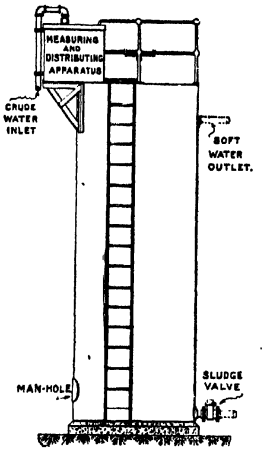


FIG. 12. ELEVATED TYPE OF "SIMPLEX" MACHINE.

It may be here mentioned that the three essential requirements of all continuous water softening machines are:—

1. Rapid and efficient softening of the water.
2. Its ready clarification.
3. Simple means of removing precipitated matter.

The first of these is the most important and is chiefly dependent upon the exactitude in distributing the required amount of chemicals. In the machine under consideration, this is effected by the particular arrangement of a "balanced" tipper and reagent cup, by the first of which, the hard water is accurately measured and then discharged, the cup measuring and distributing the reagent, whilst the speed at which the machine is worked may vary within very wide limits without its accuracy being affected. The measuring and distributing portion of the machine exhibits considerable ingenuity and originality; none of the essential parts remains under the water or reagents, whilst accurate measuring of the liquids takes place automatically without the employment of valves or nozzles.

The idea of a tipper as distinct from a "balanced" tipper is not novel. The original form consisted of a vessel divided into two parts by a partition, one part of the vessel, when full of water, falling over, and in so doing bringing the other part under the stream of incoming water. This certainly proved to be an efficient mode of measuring the water, but in the "Simplex" machine, the tipper is further utilised to actuate a stirrer for keeping the reagents thoroughly mixed. Only one chamber of the tipper is used for the reception of the incoming water, and when this is full, the tipper falls over by displacement of the centre of gravity. The chamber empties, and the tipper immediately resumes its original position; hence, it is evident, that it falls and rises each time that a measured quantity of water is discharged. The stirrer blade actuated by the tipper obviously makes a stroke in each direction every time that the tipper performs its measuring function. Thus, efficient stirring of the reagents is assured. The cup by which a measured amount of the reagent or reagents is ladled out of the container at each stroke of the tipper, is of a peculiar construction, which enables its capacity to be varied within wide limits, so that the amount of softening action upon the water can be adjusted without the necessity of altering the strength of the reagents. With regard to the second requirement, viz. :—Clarification, it is to be noted that immediately the reagent commences to act, the water becomes cloudy in appearance, and this cloudiness increases until the reaction is completed.

Evidently, therefore, no clarification can be efficiently performed until the latter result has been accomplished, so that anything which conduces to the speed of reaction will be advantageous. In the machine we have in view, the speed of the reaction is facilitated by the method of injecting the reagent into the water, and by the subsequent violent agitation of the mixture.

After being thoroughly agitated, the treated water is discharged to the bottom of the sedimentation tank, which is of sufficient size to allow of the reaction being quite completed, the water rising slowly so as to leave the bulk of the precipitated matter at the bottom of the tank, while the remaining cloudiness disappears on passing the water through a wood-fibre filter. From the top of the latter, the softened and filtered water flows away, and is discharged into the service cistern for distribution to the wash-house. The mode of working is clearly shown in the following diagrams, Figs. 13 and 14.

In Fig. 13, 1 and 2 are sectional views through the chamber F upon the Line H.H. 3 and 4 are sectional views through the

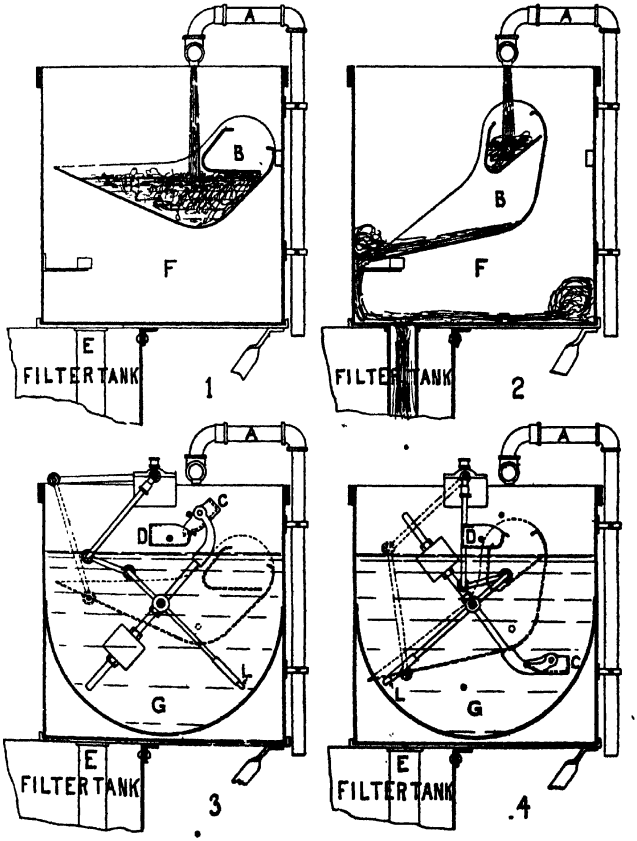


FIG. 13. MEASURING AND DISTRIBUTING APPARATUS OF "SIMPLEX" MACHINE.

reagent tank G upon the line K.K., and Fig. 14 represents a plan of the apparatus. A indicates the crude water inlet and F is the chamber in which the tipper B works.

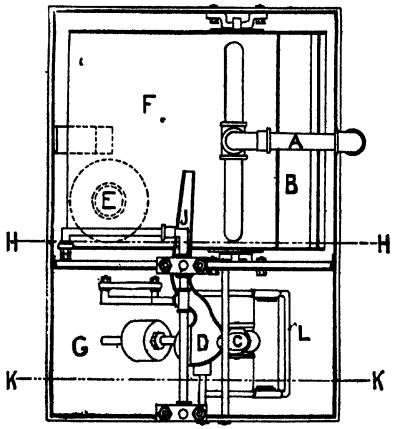


FIG. 14. MEASURING AND DISTRIBUTING APPARATUS. PLAN.

The apparatus with the tipper in the position it occupies on starting is shown at 1, while the dotted line in 3, shows it in the same position.

The crude water flows from A into the tipper B, into which the chemicals, (usually lime and sodium carbonate), are previously delivered by the method described below.

The incoming water is divided into small streams, which break up and agitate the surface of the water as it fills the tipper, and keep the whole of the water in violent motion, causing it to mix thoroughly with the chemicals. When the water has filled the tipper, the latter falls over into the position shown in 2, and in dotted lines in 4, so that the water is emptied into the tipper chamber F, and flows to the filter tanks through the pipe E.

In falling to the position shown in 2 and 4, the tipper, by means of the lever connections, moves the chemical supply vessel C to the position near the bottom of the container G, as shown in 4, where it fills with the reagent.

After the water has all flowed out of the tipper B, the latter returns to the position shown in 1 and 3, and in so doing raises the vessel C into its highest position, where it is deflected by the small stop shown, so that its contents flow into the receptacle D, whence they are emptied by means of the spout J (Fig. 13) into the tipper B.

By this means an exactly measured quantity of reagent is delivered into the tipper each time that it vibrates, and the incoming water falling into the tipper mixes in a highly efficient manner with the reagent before being delivered into the tipper-chamber F.

In the latter, the water rushes from side to side, owing to the rapidity of its discharge from B, thus causing a further mixing and agitation.

Finally it is discharged through pipe E, by its passage into and through which, the mixing and agitation are kept up until the water reaches the under side of the filter.

The efficient mixing and agitation thus set up are of the highest importance in contributing to the production of the most successful results.

The mixture in the container G is vigorously stirred twice, (once in each direction), at every vibration of the tipper, by means of the paddle L.

Lassen and Hjort Water Softener.—This plant also works on the continuous system, and is made in different sizes according

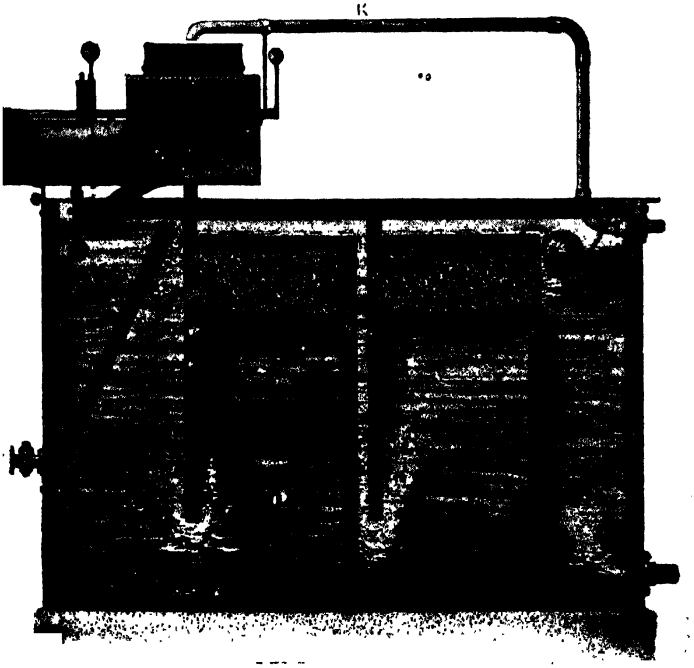


FIG 15. LASSEN AND HJORT WATER SOFTENER.

to the volume of water required per hour. The mode of working with the ordinary type of machine will be readily understood by reference to the sectional view shown in Fig. 15.

Hard water passes through the pipe K into one of the chambers of the oscillating receiver. When this chamber is filled the centre of gravity is removed and the receiver tips over, pouring its contents into the tank B immediately below, at the same time bringing the other chamber of the receiver underneath the orifice of the pipe K. On the side of the oscillating receiver is fixed a semi-circular tank D, which contains the chemicals used for treating the water. To the bottom of this tank a valve is fitted through which the reagents fall into the chamber B. A system of levers is also fitted to the receiver, and at every oscillation of the latter these levers actuate the valve in the bottom of the tank D. The lift of the valve can be regulated by two small nuts fixed on the valve spindle, so that a given volume of the solution of chemicals can be mixed with the water.

Milk of lime and sodium carbonate, or caustic soda, are the chemicals usually employed; the former is continually stirred by means of an agitator fixed inside the reagent container.

It is frequently desirable to heat the water in the intermediate tank B, in order to facilitate the chemical action between the reagents added and the solid matter in solution in the water. This may be effected either by live or exhaust steam. From tank B, the water passes into the settling tank A, where a considerable amount of precipitation takes place. It then passes upwards through the filters, which are made of wood fibre, packed tightly between two rows of wooden bars. The filters can be taken out for cleaning purposes by removing the top bars. Sludge cocks F are provided for drawing off the precipitated matter. The purified water flows into the storage tank O, which, when full, causes a float to rise and in so doing to close the valve—by means of a suitable connection—regulating the hard water supply.

The Lassen and Hjort water softener is also made in a modified form for the purification of greasy water such as is obtained by the condensation of steam from the cylinders of engines. In this case, the chemicals employed are sodium carbonate and sulphate of alumina. When these are mixed, a flocculent precipitate is produced which attracts and encloses the minute globules of oil floating in the water, so that on subsequent filtration, the oil and precipitate are retained by the filtering medium.

General Remarks.—The efficiency of any system of water-softening which involves the use of chemicals is largely dependent upon the regular addition of the correct amount of the latter

to a definite volume of the water to be treated and the subsequent removal of precipitated matter in a thorough and ready manner. The first requirement is now usually accomplished automatically by means of many different forms of mechanism; if the latter are so designed as to be easily regulated without getting out of order—especially as regards the delivery of an unvarying amount of reagents—and the crude water supply is fairly constant in composition, excellent results may be expected with very little attention to the apparatus.

With regard to the removal of precipitated matter, it has been previously stated that wood fibre is commonly used as the filtering medium. This simply consists of very thin and narrow wood shavings which are packed moderately tight and kept in position with the aid of wooden supports or by other suitable means. In a continuous water softening plant, the depth of the filtering medium needs to be carefully regulated. As a rule, the greater the surface exposed, the smaller is the depth of the filter, although the cubical content is usually governed by the capacity of the plant. If the filter is not of sufficient depth, inefficient clarification results sooner or later, while on the other hand, too great a depth may lead to a considerable waste of filtering medium, since it is very difficult to cleanse.

Cloudiness in a softened water is generally an indication that the filtering medium needs replenishing or that the plant is being worked too hard.

A fruitful source of unsatisfactory results, is the neglect to apply suitable tests to the treated water from time to time in order to ascertain its condition. Occasional testing is absolutely necessary since it is impossible to ensure a regular supply of crude water of constant composition. The latter statement applies more particularly to those cases in which the water is obtained direct from rivers, although it is also applicable, but in a smaller degree, in cases where public water supplies are utilised.

The approximate degree of hardness is quickly obtained by means of the soap test already described. If excess of lime is being used, the softened water will yield a more or less pronounced dark brown precipitate on the addition of a few drops of silver nitrate solution, while a correctly treated water should yield a faint yellow precipitate. Excess of alkali is indicated by the behaviour of the water towards phenolphthalein; a slight pink colouration is of no consequence, but the formation of a deep pink or red colour shows that too much sodium carbonate is being used.

In cases where it is essential to employ a neutral water, *e.g.*, in the malt breakdown, and a water softening plant is in use, great care should be exercised in order to guard against the presence of free alkali in the softened water. As it is a matter of considerable difficulty to regulate the quantity of chemicals so as constantly to produce a softened water free from traces of alkali, a little acetic acid may be used for neutralising purposes whenever necessary.

With reference to the quantities of chemicals required for softening any particular water, it should be noted that these are best determined by actual trial in the laboratory, using standard lime water, sodium carbonate, etc. In many cases, the quantities are calculated from the results of volumetric or gravimetric analysis, but apart from the fact that such analyses involve considerable care, experience, and the expenditure of much time, the figures obtained seldom give rise to satisfactory results in practice, *i.e.*, when used as a basis for calculating the quantities of reagents. It is well known that the hardness obtained by soap is altogether unreliable when used for the latter purpose, while the acid volumetric process is by no means trustworthy. In any case, a separate determination of magnesium is necessary in the event of salts of that metal being present in the water.

Quantities of reagents calculated from the figures obtained by gravimetric determinations are undoubtedly the most reliable, provided the analyses are carried out with very great care. For most practical purposes, however, the method first mentioned, viz. :—A trial on a small scale, yields the most satisfactory results.

An interesting departure from the recognised methods of softening water by the direct addition of chemicals, has been rendered possible by the discovery—due to Gans—that certain complex mineral substances (zeolites) possess the property of readily displacing calcium, magnesium, etc., from hard water, yielding equivalent amounts of sodium, and that artificial zeolites —which can be readily prepared—react in much the same way. Thus, according to Kolb, (*Jour. Soc. Chem. Industry*, p. 89, 1912), when the substance known as *permutite*—which is an *artificial* zeolite of the composition

$$3SiO_2,Al_2O_3,(K_2O.Na_2O.CaO),5H_2O,$$

—is used as a filtering medium for hard water, an interchange takes place between the bases of the calcium and magnesium salts and the sodium of the permutite. It is maintained, that complete softening can be effected without the production of

sludge, while the permutite can be regenerated by treating the used substance with common salt. Furthermore, it is stated that iron and manganese can be removed in a similar way, but in all cases, the water must not be acid, nor should it contain suspended matter, since there is danger of the pores of the filter becoming choked, thus rendering the permutite inert. In another system of recent introduction, the hard water is passed over aluminium plates, whereby it is said to undergo ionisation. Information concerning the practical results obtained by this method is difficult to obtain; it is stated that the scale forming salts are precipitated as sludge, instead of accumulating as a hard crust on the boiler plates.

CHAPTER IV.

The Mechanical Appliances of the Laundering Industry.

In no other branch of the textile industry is there such wide choice in the matter of mechanical appliances for carrying on the different operations as in the laundering industry. Indeed, there are so many machines differing to a greater or less extent, which are available for conducting any particular operation, that it would require far more space than is at our disposal, to describe them adequately. Still, so far as is feasible, we shall include in this Section, a representative selection of each of the various classes of machines, while special appliances, and a few machines of greater or less importance, will be described when dealing with the operations for which they are employed. The following classes are distinguished :—

1. Washing machines.
2. Wringing machines and hydro-extractors.
3. Starching machines.
4. Drying apparatus.
5. Finishing appliances.

SECTION I.—WASHING MACHINES.

The first process which soiled "linen" undergoes—after sorting and marking—is known as the washing process. It consists of a series of operations which is usually carried out in one and the same machine without removing the goods. The type of machine generally employed is known as a rotary or cylinder "washer." Its chief features are two drums or cylinders, one of which is placed within the other so as to leave an annular space between them. The outer cylinder—which is usually stationary—is made impervious to water and steam, while the inner one is made of suitable material, perforated in all parts except the ends. Axles or trunnions are fitted to the ends of the inner cylinder, and these rest in bearings attached to the end pieces of the outer cylinder. The inner cylinder is caused to revolve by means of suitable gearing placed outside the machine, while the provision of an automatic reversing arrangement causes it to make a certain number of revolutions first in one direction and then in the other. Both cylinders are provided with doors opening outwards, and attached to the outer cylinder are the necessary cold and hot water supply pipes.

In carrying out the first part of the washing process, sufficient water at a suitable temperature is introduced into the machine. The soiled "linen" is then placed in the inner cylinder, the door closed, and the machine set in motion.

The outer and inner cylinders of rotary washers are frequently made of wood, but the most serviceable machines are either partly or wholly of metal. In the latter type, the inner cylinder is usually made of brass or gun metal, while iron or steel is commonly employed in the construction of the outer cylinder, which is galvanized after it has been put together in order to retard the formation of rust. Machines with brass inner cylinders and wooden outer cylinders are also in general use.

Sizes of Machines.—Cylinder washing machines are made in different sizes, the size being frequently expressed in terms of "shirt capacity." Thus there are machines having capacities of 50, 100, and 150 shirts or more. This means that a 50 shirt machine can be employed for washing about 50 shirts, or a number of articles of equivalent weight at one operation. About 20-25 cuffs or collars, or the same number of handkerchiefs, are generally considered to require as much space in the machine as one shirt. It will be evident, however, that this system of denoting the "washing capacity" of cylinder machines is only approximately correct, and, as the dimensions of machines of "equal shirt capacities" made by different makers frequently vary to a considerable extent, it follows that the actual "shirt capacity" of a machine of this type is best determined by a few practical trials. The diameter should not be too great compared with the length, or considerable difficulty will be experienced in obtaining ready access to the "linen" contained in the inner cage. It may be noted that the term "shirt capacity" is falling into disuse, and has already been discarded by some of the most up-to-date makers.

Machines built of Wood.—Fig 16 is an illustration of the modern type of wooden washing machine. It consists of an outer cylinder of suitable wood supported on two cast-iron feet, and bound with adjustable galvanized iron bands to allow for expansion of the wood. The trunnions of the inner cylinder are carried at each end of the machine by a strong cast-iron framing, which also carries the bracket arm for the belt mechanism, so that the running parts remain in adjustment without being affected by any swelling or shrinkage of the wood.

Narrow pieces of smooth maple, termed "raisers," are fitted inside the inner cylinder. These project inwards from the staves of the cylinder, and are of considerable service in raising the "linen" out of the wash liquor from time to time during the rota-

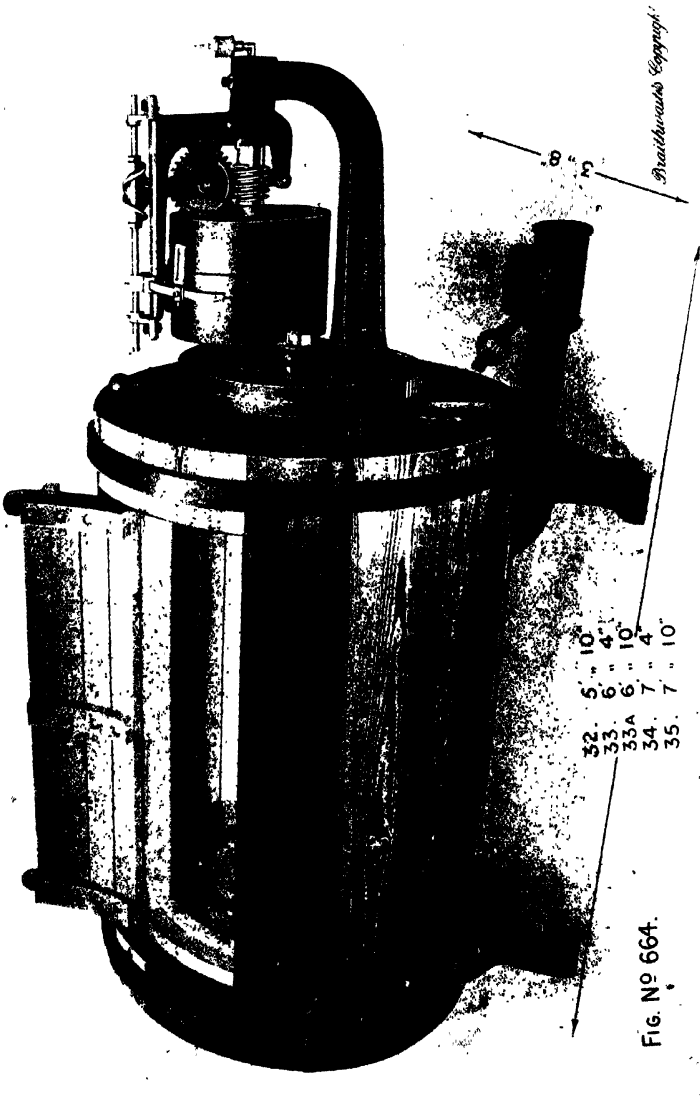


Fig. 16.—"Ibis" Wooden Washing Machine. (*I. Braithwaite and Son, Ltd.*).

tion of the machine. A steam inlet valve, hot and cold water supply pipes, and emptying cock, are fitted to the outer cylinder, while a gauge glass fixed to the outlet pipe indicates the height of the liquor when the machine is in use.

Brass Ring Attachment.—A special feature of many of the machines provided with wooden inner cylinders, is the method of fastening the trunnions or axles to the solid wooden end pieces. For this purpose a brass ring is usually employed on which a number of lugs have been cast. These lugs are drilled and tapped to receive screw bolts which pass through corresponding holes in the trunnion, so that the latter is held perfectly rigid, and the cylinder ends are less liable to wear owing to torsional strain. The "*Troy*" *Brass Ring* is shown in Fig. 17.

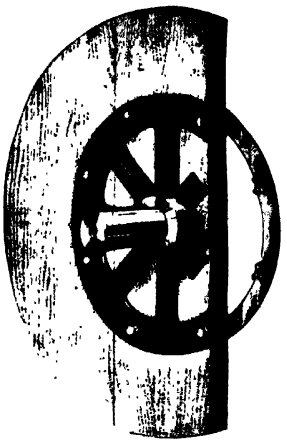


FIG. 17.—"TROY" BRASS RING ATTACHMENT.

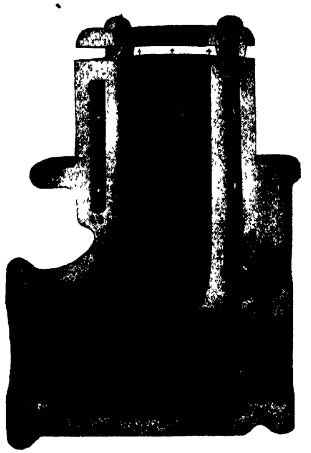


FIG. 18.—STEAM AND WATER ELL. PATENT.

(T. Armstrong and Co., Ltd.).

Attached to some machines is a special coupling called an ell or tee, which comprises a combined waste outlet and a water and steam inlet. One of these is shown in Fig. 18. The steam is admitted through the outer casing instead of passing upwards in the centre. It then passes upwards as shown by the arrows, until it arrives at several small holes; on issuing from these, it comes into contact with an iron baffle plate, which effectually prevents any direct action of the steam on the inner cylinder or upon the "linen" contained therein.

Metal Machines.—Machines made entirely of metal are invariably employed in the more important steam laundries, as well as in the laundries attached to public institutions. In a large number of laundries, however, machines with wooden outer cases and metal inner cylinders are in common use. A machine made entirely of metal possesses several advantages when compared with a wooden machine. In the first place, the material used in its construction need only be comparatively thin; secondly, a suitable metal offers great resistance to the wear and tear of the washing processes, so that renewals and repairs are not so frequent as in the case of wooden machines; in the third place, the metals employed are practically unaffected by contact with water or the usual washing liquors, while it is a matter of common knowledge, that wood is injuriously acted upon by water and alkalies, and is worn away more rapidly by the rubbing action of the "linen." The author is assured by an engineering expert, however, that the most economical type of machine for commercial laundries, is one, in which the inner cylinder is of brass, and the outer cylinder of wood; the whole being supported by an independent frame.

A typical all-metal machine is shown in Fig. 19. It is built on the same general principles as the wooden machines previously described, but the outer shell is of galvanized mild steel, while the inner cylinder or cage is of brass sheet made up in segments and perforated. The cage revolves on trunnions or shafts, the ends of which are supported on the outside of the machine by means of two smooth wheels which revolve on roller bearings. Internally, the cage is fitted with a number of brass rubbers, and is caused to make two revolutions alternately in each direction by means of automatic reversing gear actuated by belt driven pulleys. The latter are usually placed on the top of the machine end, as shown in illustration, but where space is limited they can be placed at the back, *i.e.*, with the centre of pulleys in a line with centre of cylinder, or at the bottom beneath the centre of cylinder.

The door is made the full width of cage to facilitate loading and unloading. It is fitted with a spring catch, which extends and grips the cage almost the entire width of door. The latter can be readily brought into position, whenever necessary, by means of a hand wheel and worm gear arrangement, which also actuates an effectual locking gear, thus preventing the cage from moving during the introduction or removal of the "linen."

The outer case is provided with the usual fittings, such as steam and hot and cold water cocks, gauge glass, and large emptying cock. The gauge glass is shown to the right of Fig.

19. It is combined with the outlet pipe and is of large dimensions, so that the condition and height of the wash liquor in the machine can readily be seen. The glass is well protected, and can be easily taken out for cleaning.

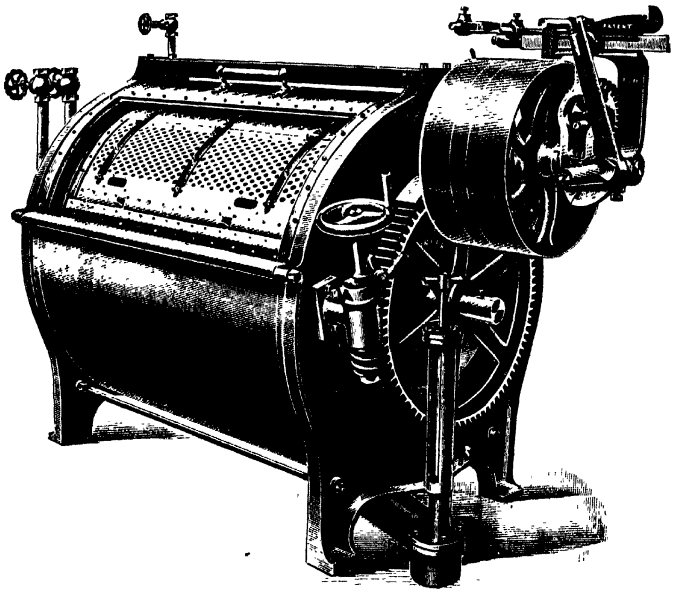


FIG. 19.—ALL-METAL WASHING MACHINE.
(*W. Summerscales and Sons, Ltd.*).

Metal Inner Cylinders.—As mentioned above, these are usually of brass; each cylinder is fitted either with a wide opening door extending its whole length or a comparatively small door. The former arrangement facilitates unloading, since it enables the operator to have ready access to the whole contents of the machine. The ends of the cylinders are made of brass plates riveted to heavy cast iron supports, and each cylinder is fitted with a series of "raisers" through which pass stay rods, thus clamping the whole cylinder rigidly together. The perforations in the circumference are stamped and embossed by special tools in order to ensure a perfectly smooth surface upon which it is practically impossible to tear the "linen."

Many modified forms of the standard type of metal inner cylinder, *i.e.*, the plain cylinder with perforations all over, have

been introduced by laundry engineers, and those of particular interest are described below. It should be noted, however, that each of the cylinders illustrated, is a speciality of the firm by whom it is made, and does not, of course, represent the only kind manufactured.

The side plates of inner cylinders are built up either in segments or in one piece. In one type, the longitudinal edges of the segments are bent inwards, and attached to V-shaped pieces of metal, which act as "raisers" or "rubbers" (Fig. 20). These exercise a

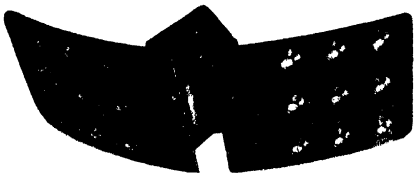


FIG. 20.—SECTION OF INNER CYLINDER, SHOWING MODE OF JOINING SEGMENTS.

(D. and J. Tullis, Ltd.).

rubbing action on the "linen" and assist in turning it over while the machine is in motion. By adopting this mode of construction, both the rivets used for joining the segments and the line of joining are covered by the "rubbers," so that the heads of the rivets are not liable to become worn and ragged by the rubbing action of the goods. In addition, the "rubbers" are so designed that they are filled with the washing liquor at every revolution, and subsequently discharge it on to the "linen" at an angle of about 60°.

Fig. 21 shows a cylinder provided with another type of V-shaped "lifter" or "raiser," of which there are four. The cylinder is thus divided into four spaces, into each of which, the "linen" drops alternately during the revolution of the machine. Only the "V's" are perforated, so that the wash liquor is forced into the cylinder as each "V" comes into contact with it during each revolution.

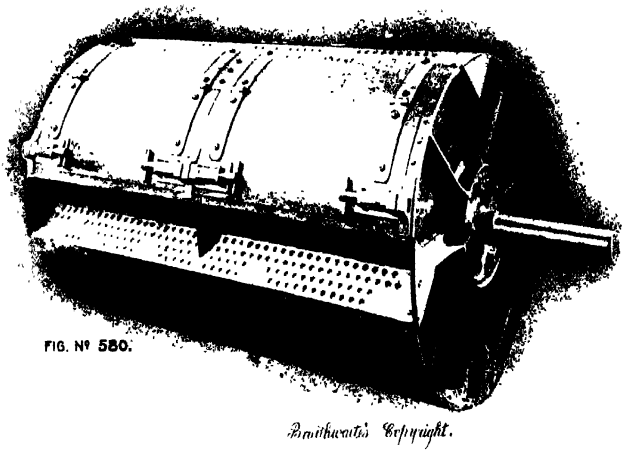


FIG. 21.—INNER CYLINDER WITH V-SHAPED "RAISERS."
(J. Braithwaite and Son, Ltd.).

In a cylinder of recent introduction (Fig. 22), the perforations take the form of comparatively large scoops, which undoubtedly facilitate the flow of the liquor in and out of the cylinder.

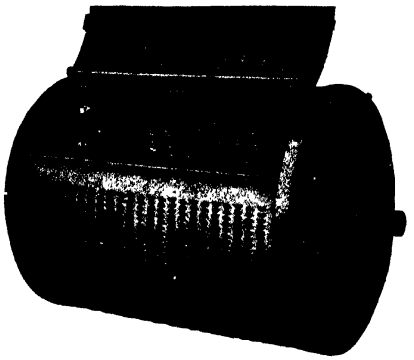


FIG. 22.—"TURBINE" INNER CYLINDER.
(J. Armstrong and Co., Ltd.).

The provision of small "scoops" or "buckets" for the same purpose is the chief feature of the "Injector" washing machine. These scoops are arranged continuously over the whole of the inner cylinder (Fig. 23).

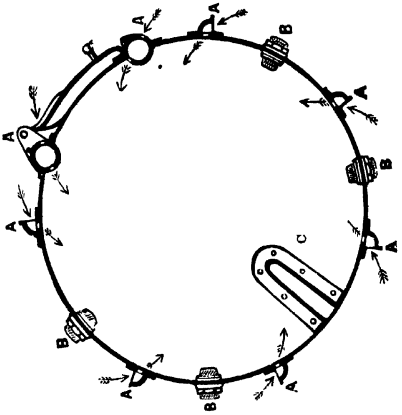


Fig. 24.—End Section of Fig. 23.

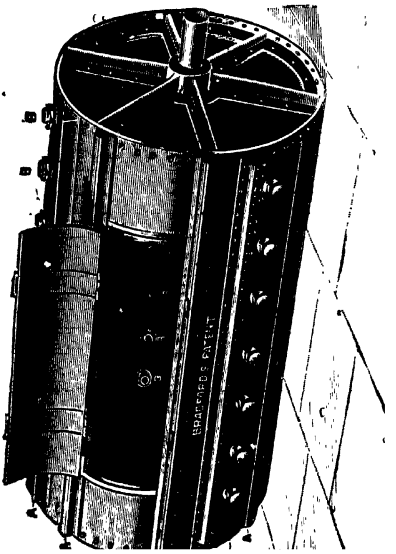
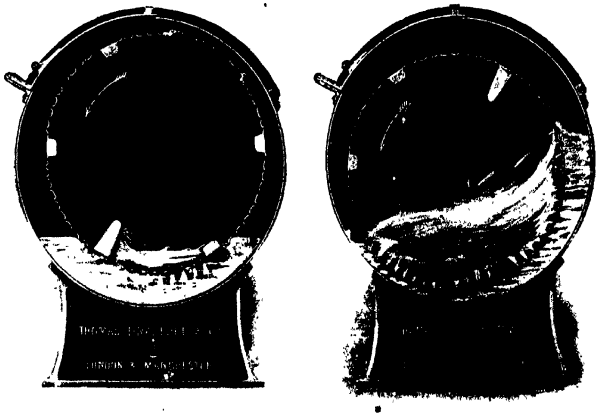


Fig. 23.—Inner Cylinder of "Injector" Washing Machine.
(*T. Bradford and Co.*).

As the latter revolves in a certain direction the water from the outer cylinder is lifted up by the scoops A, and injected equally over the whole of the "linen" in the interior; when the motion of the cylinder is reversed, the water is ejected from the goods. It is evident, therefore, that the saturation of the "linen" with liquid is accomplished by the injection—with the force acquired during the "forward" motion of the rotating compartment—of the soap liquor placed in the outer compartment, into and upon the "linen" in the rotating compartment. The motion of the latter then reverses automatically, and, during the backward motion, most of the soapy liquor is ejected back again into the outer compartment. During this alternate forward and backward motion—but more especially during the backward motion, *i.e.*, when the goods contain the least amount of water, and thus are in the proper condition to be subjected to a frictional process of cleansing—the articles undergo a kneading action by means of the midfeather C, (Fig. 24), and rubbers B, which surround the interior of the inner cylinder.



Position when inner cylinder contains smallest amount of water. Position when inner cylinder contains largest quantity of water.

FIG. 25.—"SURGAR" WASHING MACHINE. END SECTIONS.
(*T. Bradford and Co.*).

The "Surgar" Inner Cylinder.—This type of cylinder differs from those previously described in that it is fixed eccentrically on its bearings, thus causing it to rise and fall during each revolution. Fig 25 represents sections of the cylinder at different points during its revolution. It is claimed by the makers, that the whole of the wash liquor, or rinsing water, as

the case may be, is forced through the "linen" at each revolution, whereas in the ordinary type of machine, a considerable proportion of the liquor lies dormant in the outer cylinder. Among the advantages put forward are the following :—1. Quicker and better work, whether in washing or rinsing. 2. Great economy of soap and water. 3. All the washing liquor is fully utilised.

Patent rubbers are fitted to the inside of the cylinder and also a "midfeather," which latter lifts the goods and drops them into the water at each revolution.

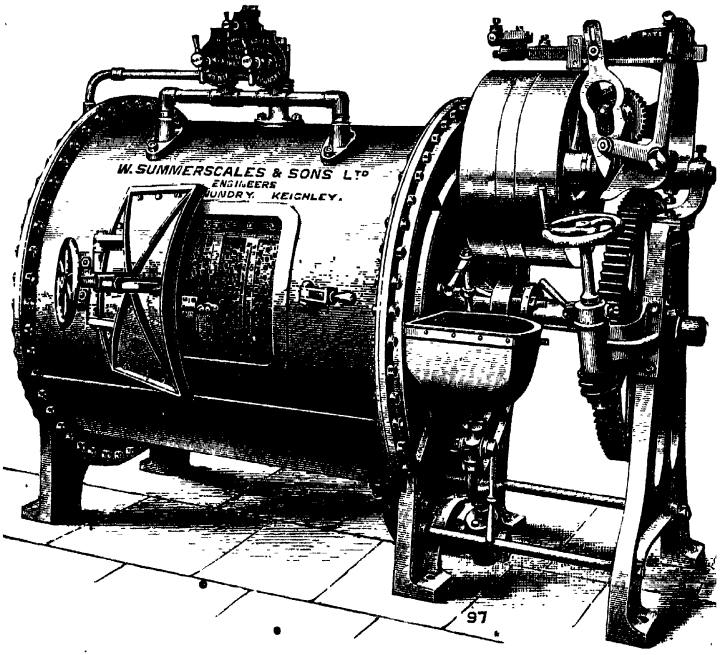


FIG. 26.—"PRESSURE" WASHING MACHINE.

In the "*Dasher*" *Washing Machine* of Messrs. Appleyard, a series of V-shaped projections is riveted to the inner cylinder, while similar projections are attached to the outer cylinder. The projections on the latter are so arranged, that when the inner cylinder revolves, the open ends of the "V's" on its surface, catch the wash liquor, and dash it with considerable force against the open ends of the "V's" on the interior of the outer cylinder. In this way, the liquor is forced under pressure through the perforations in the cylinder.

Pressure Washing Machines.—It is the custom in many laundries to boil certain classes of goods under a steam pressure of a few lbs. per sq. inch, for which purpose so-called pressure washing machines are employed. A typical representative of this class is shown in Fig. 26. Its chief features are very similar to those of the ordinary type of machine, but special provision is necessary in order to prevent the escape of steam when in use.

The outer cylinder is made of steel, and the end bearings, which support the inner cage, are made of sufficient length to enable them to be fitted with glands and stuffing boxes, so as to form steam-tight joints. With the same object in view, the hinged outer door is padded with an asbestos cushion, which closes against a strong mouthpiece, and is bolted in position by means of a hand screw.

The inner cylinder is of brass perforated, and is made extra strong in order to prevent "buckling." A hand wheel and worm arrangement enables the door to be readily brought into position for loading and unloading, and at the same time locks it in position. The washing liquids may be introduced by means of a funnel-shaped opening with stopcock attached to the side of the machine, thus obviating the necessity of opening the door until the goods have been completely washed.

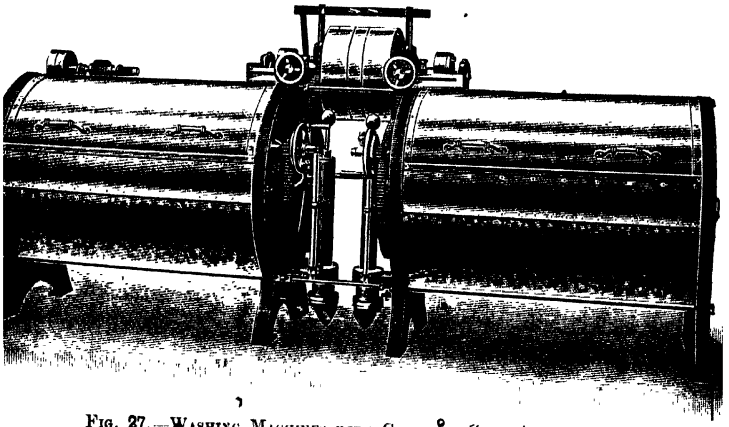


FIG. 27.—WASHING MACHINES WITH COMBINED GEAR ARRANGEMENT.
(*J. and J. Lane, Ltd.*).

Driving and Reversing Gear.—Practically the same type of driving and reversing gear is used both for metal and wooden machines. It is usually placed at one end, but in many cases—especially where space is limited—it is elevated at the back of the machine. Space may also be saved by coupling two machines

together, a combined gear arrangement being placed in the centre as shown in Fig. 27. Either of the machines in this arrangement may be used separately.

As a general rule, the reversing motion is obtained by means of fast and loose pulleys with a direct and cross driving arrangement, the belt being shifted automatically by means of forks actuated by a worm and worm wheel gear. In the combined gear arrangement referred to above, the reversing motion is so designed as to be quite independent of the main driving gear; it can be placed anywhere on the back of the machine, so that the space between the two machines is only just sufficient for three driving pulleys and the spur gearing. In addition to this arrangement, which results in a considerable saving of space, the driving gear bearings are bolted on to horizontal surfaces cast on the heads, hence the whole gear can be readily removed by undoing a few bolts. The larger machines are double geared in order to prevent an unequal strain on the inner cylinder. Both the outer shells and inner cylinders of many types of wooden double geared machines can be readily taken out without disturbing the mechanism. Fig. 28 illustrates a "*Troy*" *Iron Standard* or support with double gear—including intermediate gear—and elevated driving and reversing mechanism or "header."

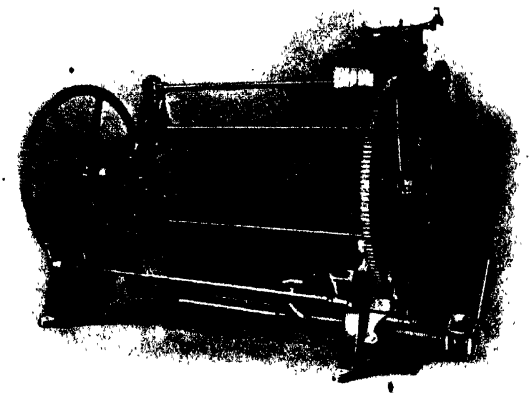


FIG. 28.—"TROY" IRON STANDARD WITH DOUBLE GEAR.
(J. Armstrong and Co., Ltd.).

As already mentioned, the majority of cylinder washing machines are fitted with a type of driving and reversing gear which causes the inner cylinder to make a certain number of revolutions in one direction and then the same number in the opposite

direction. The actual number of revolutions made in either direction, however, and the number of revolutions per minute vary to a greater or less extent in different machines, but it is becoming more and more recognised that a greater speed than from 14-20 revolutions per minute is totally unnecessary; also, that from 1 to 1½ revolutions in each direction are quite sufficient for most purposes.

Excessive speed and several revolutions of the inner cylinder in each direction cause the "linen" to be pressed to the sides of the cylinder by centrifugal force, and it is dashed into and out of the water at every revolution. As a result, the goods are apt to become entangled and are injuriously affected by unnecessary friction. If the inner cylinder is revolving at the rate of about 20 revolutions per minute, however, and reversing after 1½ revolu-

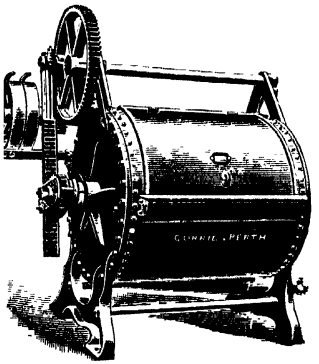


FIG. 29A.—WASHING MACHINE WITH RACK GEAR.

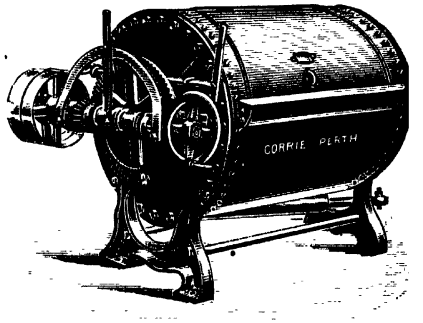


FIG. 29B.—ROTARY WASHER WITH POSITIVE GEAR ATTACHED TO MACHINE END.

(*D. Gorrie and Son*).

tions in either direction, the "linen" is gently lifted only a short distance by the "raisers" or "rubbers," and then turns over by its own weight assisted by the action of the succeeding "raisers" on the rest of the goods. In this way, the latter are caused to roll over each other continuously, and are not subjected to a high drop and excessive friction. If fine and delicate goods are washed in cylinder machines, the latter should not exceed a speed of about 14 revolutions per minute and the reversing gear should act after 1 to 1½ revolutions, while it is of considerable importance that an equal number of revolutions should take place in either direction, for inequality in this respect is liable to cause the goods to become entangled, and thus lead to defective washing. With the ordinary type of reversing gear, the number of revolutions in each direction is not exactly the same, owing to the difference in the amount

of "slip" on the two driving belts. Hence, there is a greater tendency for the goods to become more entangled under such conditions that when the number of revolutions in each direction are exactly equal.

Rack and pinion gear is sometimes employed in order to obtain a single positive motion in each direction. Fig. 29 A, is an illustration of a machine working on this principle. It resembles the ordinary type of metal machine in most other respects. Rack gear machines are of considerable service for washing lace curtains and all articles of a frail nature.

Other forms of mechanism have been introduced with the object of imparting a positive motion to the inner cylinder; one of the best known of these is attached to the end of the outer cylinder (Fig. 29 B), thus economising space. It may be arranged to give from $1\frac{1}{2}$ to 3 revolutions in each direction.

Compartment Washing Machines.—The introduction of the compartment "washer" was primarily due to the demand for a machine which could be utilised for washing small lots of various classes of goods separately at one operation.

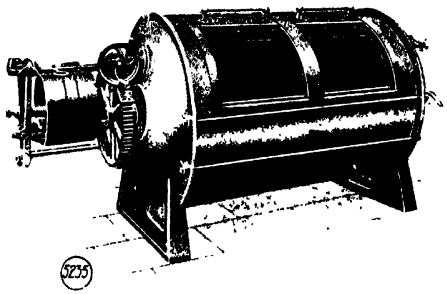


FIG. 30.—"MODERN" ROTARY WASHING MACHINE WITH VERTICAL PARTITION.
(*Mayflore, Alliott and Co., Ltd.*).

Machines belonging to this class are built on the same plan as the ordinary type of "washer," but the inner cylinders are divided into compartments by suitable partitions. It is maintained that the use of these machines facilitates the handling of the goods, while, owing to the small quantity in each compartment, less entanglement takes place than in the ordinary machine. The partitions employed to form the compartments may be either vertical or horizontal. The latter form of partition is usually perforated. A machine with an inner cylinder divided by a vertical partition is shown in Fig. 30. As a rule, a door is provided for

each compartment, two doors being fitted on a cylinder with one division, and three doors on a cylinder with two partitions, *i.e.*, three compartments. In the case of horizontal partitions, the trunnion which carries the inner cylinder, passes through from end to end, thus serving as a support for one end of each division. In some cases both vertical and horizontal partitions are employed, so that a cylinder with three horizontal and two vertical partitions would be divided into nine compartments.

The "Troy" Rapid Washer.—This machine, (Fig. 31), belongs to the compartment type, but differs from the machines already described in several important particulars. One of its chief features is the provision of specially designed water and steam connections. A perforated iron pipe, closed at one end, and extending the whole length of the machine, is laid in a groove made in one of the staves of the outer cylinder. The perforations in the pipe point upward so that the water is thrown against the inside of the outer cylinder at the top, thus preventing the undue accumulation of scum on the parts of the cylinder with which it comes into contact. It is maintained that this method of

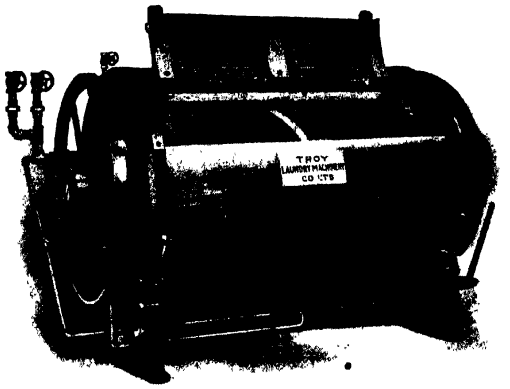


Fig. 31.—"Troy" Rapid Washer.
(*J. Armstrong and Co., Ltd.*).

introducing the water causes the temperature to be less variable in different parts of the "linen" than is the case when warm or cold water is introduced at one end of a machine containing hot articles. A patent inlet and outlet combination tee is fitted in the outer cylinder, and the outside opening of this tee is connected to a steam injector or syphon, which communicates with the steam supply pipe and also with the perforated distributing pipe. By

means of this arrangement, the necessary water can be introduced into the outer cylinder in a comparatively short period of time, since it enters the cylinder both through the perforated pipe and through the tee. The use of the steam injector may be explained as follows:—When sufficient water has been introduced into the cylinder, the water cock is closed, and the steam cock opened. During the passage of the steam through the injector, a partial vacuum is produced, and thus a considerable suction is exerted on the water in the cylinder, causing it to be forced by way of the tee through the injector and then into the cylinder again by means of the perforated pipe. In this way, not only may a continuous circulation be kept up, but at the same time, the water is heated. A patent strainer is fitted in the pipe

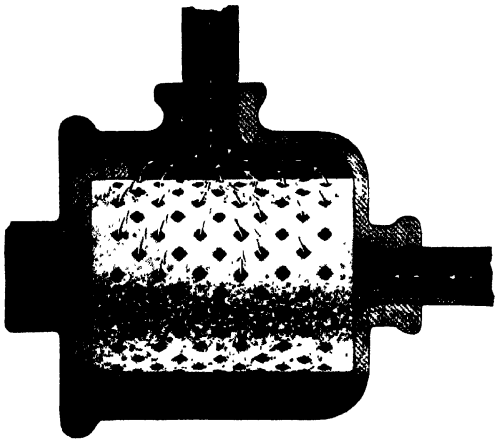


FIG. 32.—STRAINER. PATENT.
(*J. Armstrong and Co., Ltd.*).

between the injector and the perforated pipe. An enlarged view of this is shown in Fig. 32. It is used for the purpose of catching all lint, buttons, or other articles which may pass from the outlet tee; it can be easily opened for cleaning.

The inner cylinder of the machine is shown in Fig. 33. A noticeable feature is the central dividing portion, which is fixed in a slanting position. The advantages claimed for this mode of construction are as follows:—

1. An entirely new motion is given to the "linen," viz., a side rolling motion ending in a squeeze against the end of one compartment and a spread in the other. The next half-turn is just the reverse, and so on, alternating every half-turn.

2. The water or other liquid in the machine is agitated in such a way that the liquid is forced from end to end of the cylinder.
3. The goods do not get the high drop they would in same size cylinder without the slanting partition, only getting the full drop every half-turn.
4. A saving of time is effected.
5. The machine can be built with the inner cylinder running within half an inch of the outer cylinder, so that less water is required than in the ordinary machine.

In addition to these advantages, it is claimed that the use of the patent steam connections result in the following further advantages:—

1. The saving on the machine itself as well as on the "linen," owing to the fact that direct steam cannot come into contact with either. 2. Economy in steam, and 3. A constant circulation of water, or washing liquor. According to some authorities, it is inadvisable to employ wooden machines, in which the inner cylinder is placed too close to the outer one, since any swelling of the wood may easily cause serious defects.

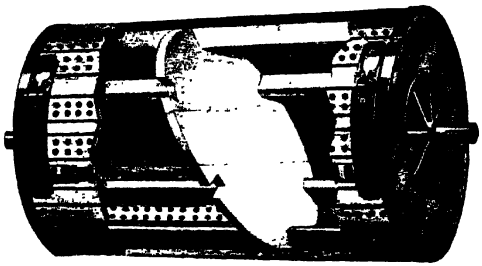


FIG. 33.—"TROY" RAPID WASHER. INNER CYLINDER.

It will be evident from our description of the foregoing types of rotary machines, that, when in use, the goods contained therein, are turned over and over by the motion of the inner cylinder, and at the same time the liquid in the outer cylinder is subjected to considerable agitation, which causes it to pass alternately in and out of the inner cylinder by way of the perforations. In this way, circulation is set up and does not cease until the machine stops. In the machine just described, however, the circulation is independent of the motion of the inner cylinder, and it is stated to be more uniform and efficient.

Apart from any advantage gained by efficient circulation, it is to be noted, that the soap liquor soon becomes dirty, just as

is the case when the ordinary form of machine is used; consequently, with either type, the "linen" is treated at one period of the washing process with a continuous stream of dirty soap liquor containing a greater or less amount of solid matter in suspension, and at the same time it is subjected to considerable friction by the motion of the inner cylinder. Treichler maintains, that in his system of washing—which we will now describe—friction is reduced to a minimum, while dirty soap liquor is not forced through and against the goods, but is allowed to percolate slowly through them.

Treichler's Washing System.—In this system, the goods are first given a preliminary treatment by subjecting them to the action of hot soap liquor in an open boiling vessel or kier provided with a false bottom, a centrifugal pump being used for circulating the liquor from bottom to top. By means of this treatment, the bulk of the dirt is removed, and, as the goods are stationary during the operation, there is less danger of damage than in the rotary machine process. During the circulation of the liquor, a cotton cloth is tied over the mouth of the distributing pipe so as to prevent effectually the contamination of the goods with any scum or other solid matter which may be present in the liquor. From this apparatus, the goods are carried to Treichler's washing machine, sections of which are shown in Figs. 34 and 35. It consists of a cast iron framework carrying an outer drum G,

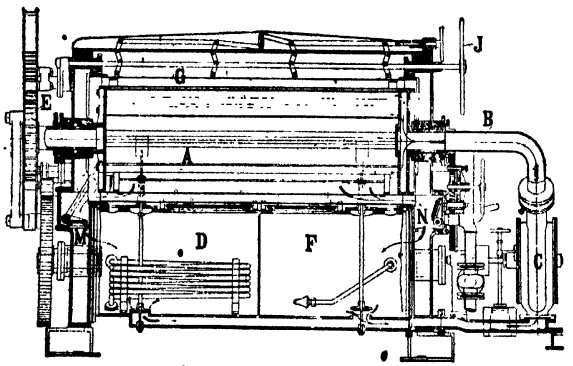


FIG. 34.—TREICHLER'S WASHING MACHINE. SECTION.

inside which is placed an inner drum A of galvanized iron. The latter drum is fitted round its periphery with squirt pipes in the form of hollow perforated ribs. These ribs are attached to the drum ends, which latter form a box communicating with the hollow bearings carrying the cylinder. One of the bearings is connected

to two vessels D and F by means of the connection B. D and F serve as reservoirs for soap and water. Either reservoir may be connected by means of a valve with the suction pipe, so that at will, either soap and water, or rinsing water, is drawn by the pump C, and delivered into the drum A. The liquor is forced under pressure through the perforations in the hollow ribs into the drum A, and thus the jets of water or other liquid dash on to the "linen" with considerable force. The liquor streaming from the inner drum is collected in the outer drum, and runs through the valves M and N back into one or another of the reservoirs.

In the reservoir D, containing soap and water, there is placed a closed steam coil, while steam may be blown into reservoir F, by means of the injector used for heating the rinsing water.

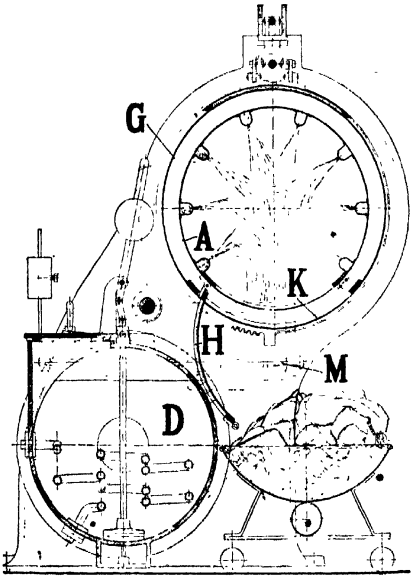


FIG. 35.—END SECTION OF FIG. 34.

In order that the "linen" may be subjected to the action of the jets of water in all parts, the drum A, is slowly revolved, the speed being only sufficient to open out the goods and to prevent them from forming into a ball.

The driving gear consists of a toothed wheel fitted to the drum and connected to another wheel which is actuated by a suitable pulley.

The outer drum G is carried on a revolving bearing fitted to the machine frame and can be revolved by means of the hand wheel J and toothed gearing.

Fourteen revolutions of the inner drum per minute are quite sufficient to keep the articles in an open state, so that they may be subjected to a thorough cleansing by means of the jets of liquor. After allowing the soap and water to run off into the reservoir D, the pump discharges large quantities of hot rinsing water over the goods. The water then finds its way back to the reservoir; any dirt rises to the surface and is carried off automatically by an overflow. As soon as the water in the reservoir appears clear, a little blue is added and the washing process is then practically at an end, having lasted about three-quarters of an hour.

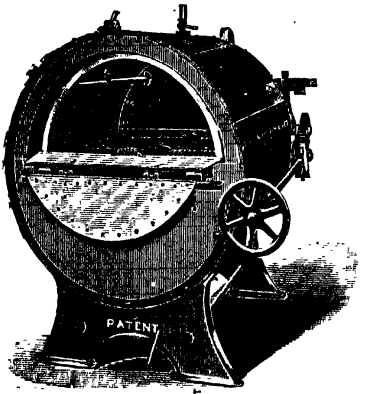


FIG. 36.—"OPEN END" WASHING MACHINE.

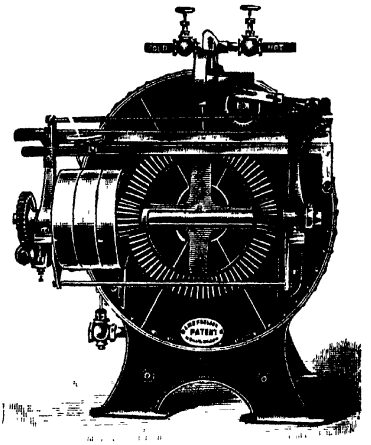


FIG. 37.—END VIEW OF FIG. 36.

(*Hill and Herbert, Ltd.*).

It is maintained, that, with this system, there is not the slightest risk of damage to the finest material.

"Open End" Washing Machines.—One of the best known washing machines belonging to the class known as "open end washers" is shown in Fig. 36. It consists of a perforated inner cylinder of gun metal and brass and an outer shell of steel plate. Large doors are fitted to both cylinders, in order to facilitate the processes of loading and unloading, while a perforated horizontal partition in the inner cylinder lifts the "linen" out of the washing liquor at each revolution, and also acts as a drainer when the

machine is at rest, *i.e.*, immediately before the unloading begins. The inner cylinder is provided with a central shaft of steel which gives additional strength and prevents twisting. It is stated that goods become less entangled in "open end washers" during the washing process than is the case when the ordinary form of machine is used, and, as the mode of construction enables the operator to obtain easy access to the articles, it is evident that they can be readily removed without much strain. This type of machine undoubtedly offers many advantages when dealing with lace curtains and other fine goods which have become weakened by wear, or by long exposure to air and light.

Fig. 37 shows the single belt driving gear which is situated behind the machine. The latter is placed at right angles to the overhead shaft, so that a considerable saving in space is effected.

SECTION II.—WRINGING MACHINES AND HYDRO-EXTRACTORS.

After the goods have been washed the excess of water is taken out of them before drying or starching either by means of a wringing machine or a hydro-extractor. The type of wringing machine in general use is built on the same lines as the common household wringer, but, as a rule, it is made of stronger materials and usually provided with driving gear for power. Wringers are either attached to frames of a convenient height for working, or made with projecting flanges for bolting to suitable supports.

The mode of action is comparatively simple, the wet goods being merely passed between two wooden or rubber squeezing rollers. One of the rollers is connected to the driving gear and the other is caused to press upon it either by means of a hand screw and spring arrangement, as shown in Fig. 38, or a lever and weights. Thus the rollers are caused to revolve in opposite directions, the motive power being furnished by belt gearing, or in many cases by hand. Fig. 39, represents a type of wringer which has been specially designed for use in collar and cuff factories. In this machine the pressure is obtained by a system of spiral springs and levers worked by a small hand wheel at one end of the machine, so that a wide range of pressure is obtainable as well as a parallel nip all along the rollers. This type of wringer is frequently used in handkerchief factories. A special feed is fitted for rapid work.

Wringing is best done with the aid of a machine provided with rubber rollers, although the latter should not be used for squeezing hot goods. There are several objections to the use of wooden rollers except for low quality goods and in special processes at elevated temperatures. In the first place they lack a sufficient amount of elasticity to prevent damage to the goods sooner or later. Secondly they wear very unevenly and in the third place the squeezing is not always uniform, especially when the rollers have become worn. On the other hand, however, they are not so expensive as rubber rollers.

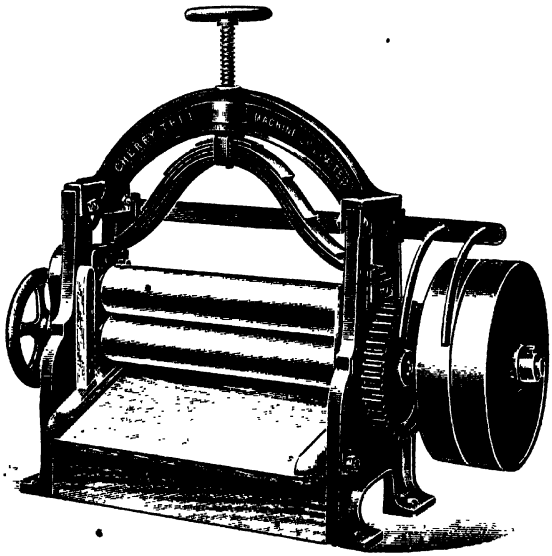


FIG. 38.—PORTABLE WRINGING MACHINE.
(*Cherry Tree Machine Co., Ltd.*).

The rubber roller machines are now universally employed in laundry work. In addition to their general utility, they are very serviceable for the removal of water and starch from goods which have been starched by hand. They are also employed to a large extent in collar and cuff laundries for the purpose of removing excess of "double" starch after the starching operation. Safety guards are usually fitted on all power wringers.

Hydro-Extractors.—The most efficient method of removing excess of water from textiles is dependent on the fact that all

parts of a rotating body have a tendency to fly off at a tangent, *i.e.*, they obey the well known law which states that a body in

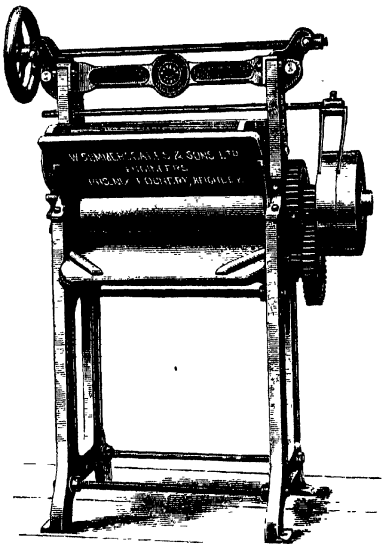


FIG. 39.—"VULCAN" WRINGER.
(*W. Summerscales and Sons, Ltd.*).

motion travels in a straight line unless it is influenced by some external cause. The force exerted by a rotating body in this way is called centrifugal force. If the body is designed so as to act as a container for solids, and wet "linen" is introduced, it will be obvious, that, on rotation, both the goods and the water they contain will be thrown off at a tangent from the axis of the container. Hence the separation of the water under such conditions is a comparatively simple problem. Machines working on the above principle are commonly known as hydro-extractors or "hydros." They are extensively used in all branches of the textile industry. A hydro-extractor comprises three main features, viz. :—

1. A circular cage or container.
2. A vertical central shaft.
3. An outer stationary case.

The cage is balanced on the central shaft and has an open top for the introduction of the "linen." It is usually made of steel, heavily galvanized, although copper and bronze are often

employed. The periphery of the cage is either perforated or wired, in order to allow the water to escape into the outer case, from which it passes through an outlet into the nearest drain.

Many types of hydro-extractors are in general use in laundries, the majority being driven by belts and gearing. Owing to the great strain on the motive power when starting the machine, however, it is of great advantage in some cases to employ a direct driven machine.

Hydro-extractors may be distinguished as over-driven and under-driven. The chief feature of both types is the contrivance for enabling the central shaft to readily adjust itself when revolving at a high speed so as to render the cage self-balancing. In the over-driven type the shaft is suspended from above, while

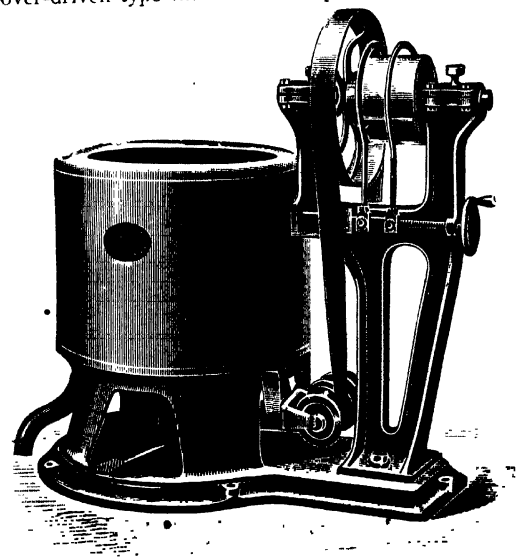


FIG. 40.—HYDRO-EXTRACTOR WITH ATTACHED COUNTERSHAFT.
(Cherry Tree Machine Co., Ltd.).

the shafts of under-driven machines rest on footsteps. The speed varies from about 700-1,400 revolutions per minute; the greater the diameter of the cage the less is the speed. Fig. 40, represents an under-driven type of machine provided with an attached countershaft. In other forms of this type of machine, a separate countershaft is fitted overhead, (Fig. 41), or it may be placed at right angles to the cage.

The outer stationary casing is of mild steel with galvanized steel rim. The cage is of steel perforated or of copper tinned inside. In the former case, it is heavily galvanized after manufacture in order to retard the formation of rust; it is firmly attached to a steel spindle which runs in a ball bearing footstep, working in a gun metal sleeve, and is held nominally in position by means of solid rubber buffers. These buffers enable the cage to adjust itself readily to suit the inequality of its load and also prevent the transmission of vibration to the building.

The driving pulley attached to the spindle acts as a reservoir for grease, which latter is distributed in a uniform manner, thus ensuring efficient lubrication. The countershaft is attached to

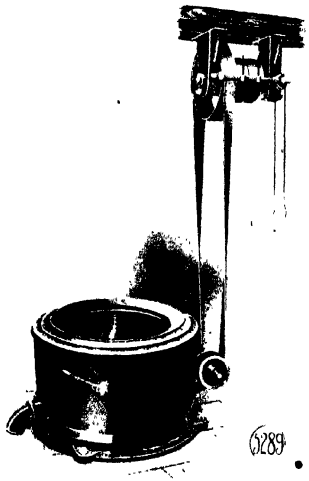


FIG. 41.—HYDRO-EXTRACTOR WITH OVERHEAD COUNTERSHAFT.
(*Manlove, Alliott and Co., Ltd.*).

the machine as shown in illustration; it is provided with fast and loose pulleys, belt striking gear, and an automatic friction clutch; the latter prevents undue strain on the belt and motive power when starting the machine.

In another form of under-driven machine the motive power is furnished by a small motor or steam engine built into and forming part of the machine.

Fig. 42, shows a typical representative of the under-driven form of hydro-extractor in section. In this machine the cage is suspended in the rigid outer casing by means of a steel shaft

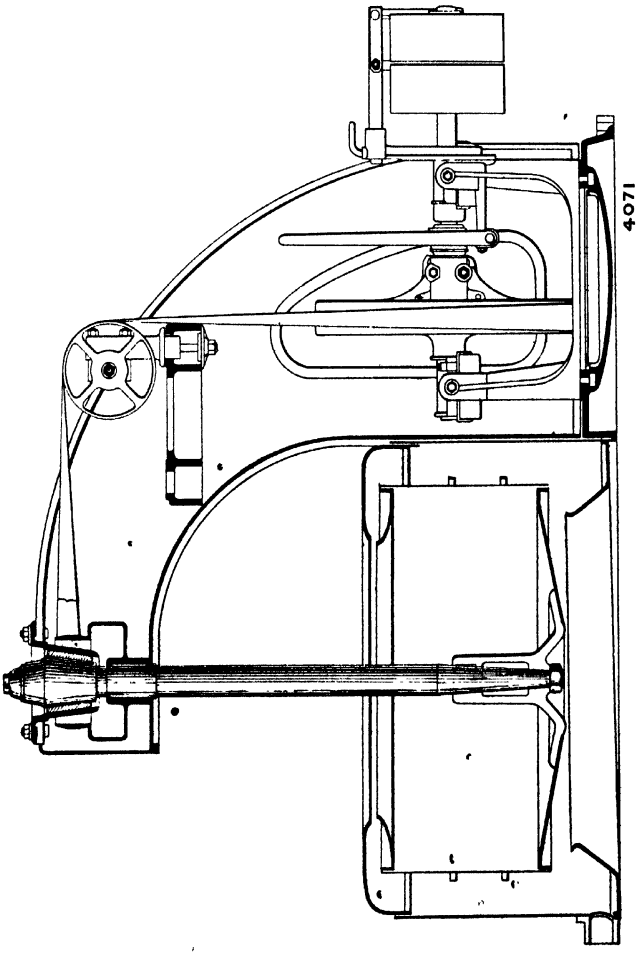


Fig. 42.—Top-Driven Suspended Hydro-Extractor. (*Watson, Laidlaw and Co., Ltd.*).

attached to a conical self-balancing bearing in an overhung frame. The machine is belt-driven, but may be driven direct by means of a small steam engine or electric motor.

The difficulties formerly associated with the efficient lubrication of hydro-extractors have been overcome by the use of ball bearings, since these only need greasing occasionally. Hence, there is little danger of the "linen" becoming contaminated with oil stains.

Fig. 43A, shows the latest form of the *Watson-Laidlow Bearing* with patent rubber buffer. It is stated by the makers that by the use of the latter, the cage will run with a much greater unbalanced load than has hitherto been possible, while, as the buffer is conoidal in form, it is self-adjusting, so that screws or nuts for tightening purposes as the buffer wears are not required.

A similar type of bearing (Fig. 43B), is employed in the construction of the under-driven machines made by the same firm, while Fig. 43C, represents a sectional view of the *Pott, Cassels, and Williamson's* form of *Ball-Bearing* with self-adjusting buffers. In this arrangement, the side pull of the spindle and cage is taken on the top and bottom rows of balls, and the oscillation and weight of the cage by the two middle rows of balls. As the buffers are separated by a loose ring, the total load is carried by both buffers, so that any wear is taken up by the compression of the rubber. This arrangement controls a large unbalanced load without transmitting vibration to the frame. Both bearing and buffers can be easily removed without dismantling the machine, and lubrication is effected by means of a little grease applied at comparatively long intervals.

When loading hydro-extractors, care should be taken to place the goods evenly round the sides first, afterwards placing other goods in the centre. If the machine is unevenly loaded it will begin to rock and may be seriously strained. A foot or hand brake is generally provided for quickly bringing the cage to rest after the belt or clutch has been removed, but it should not be applied until the machine has slowed down.

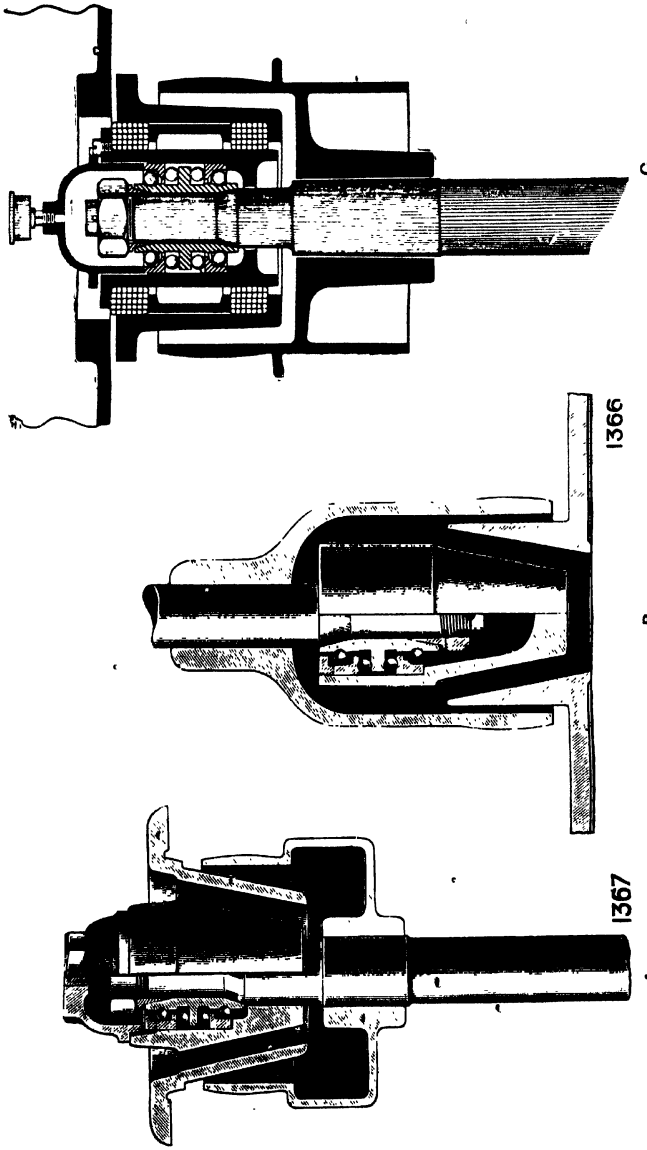


FIG. 43.—TYPES OF BALL BEARINGS FOR HYDRO-EXTRACTORS.

SECTION III.—STARCHING MACHINES.

The treatment which the goods undergo after the removal of excess of water depends upon the kind of "finish" required.

Wool and silk goods, as well as many miscellaneous articles which need to possess a soft "handle," are dried in one or other of the various types of drying rooms.

Certain classes of goods, such as collars, cuffs, and the bosoms, neckbands, and cuffs of shirts, require a "stiff" finish," while table cloths, serviettes, and many other flat goods have to be finished in such a way as to render them neither too stiff nor too soft, *i.e.*, a medium "finish" is required. In many hotels and restaurants, however, table "linen" is used which is finished by ironing only, no stiffening material whatever being employed. As a rule, this mode of procedure only gives satisfactory results with the highest quality of linen goods.

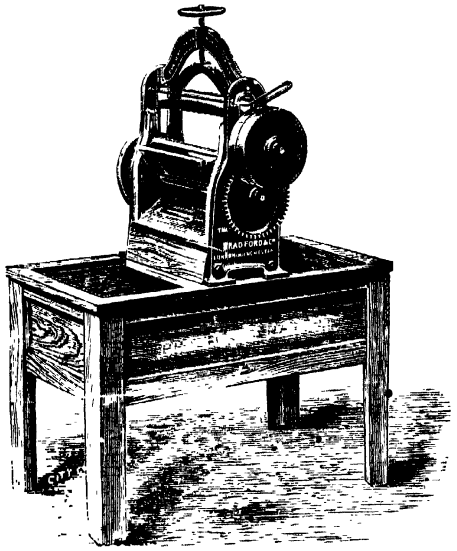


FIG. 44.—STARCHING TROUGH.
(*T. Bradford and Co.*).

For the production of a stiff or medium "finish" on articles of linen and cotton, it is necessary first to impregnate them with some substance or substances, which, under suitable conditions, are capable of binding the fibres together into a more or less stiff and

coherent mass without sacrificing too much pliability. Starch is commonly used for the purpose, and the operation is known as starching. It may be carried out either by agitating the articles in a trough, or machine, containing starch suspended in cold water, or by working them in a paste made by treating starch with boiling water. We may thus distinguish between the raw starch process and the "boiled" starch process.

Many flat goods which require a medium "finish" are starched in the washing machine, during the final rinse of the washing process, a little boiled starch being added to the water for the purpose.

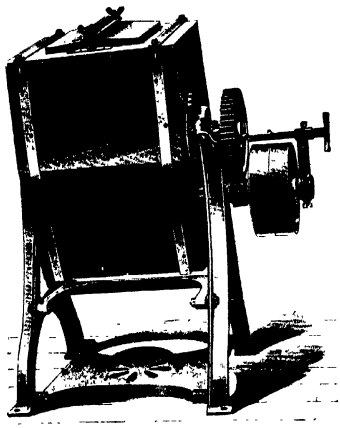


FIG. 45.—"DIP-WHEEL" STARCHING MACHINE.
(*D. and J. Tullis, Ltd.*).

The simplest form of apparatus employed for starching purposes consists of a water-tight trough of wood, to which steam can be supplied by means of an open copper pipe fitted near the bottom. The articles to be starched are simply agitated for a short time in a warm boiled starch paste contained in the trough; they are then squeezed by passing them between two rubber covered rollers attached to the apparatus (Fig. 44). The surplus starch is thus removed and falls into the trough to be used over again. This apparatus is very useful for starching light goods such as lace curtains and other articles which are washed in bags; it may also be used for blueing and rinsing.

Collar, Cuff, and Shirt Starching Machines.—Mechanical appliances are now generally employed for starching collars, cuffs, and the parts of shirts that have to be highly stiffened. For this

purpose a large number of machines are available and they may be divided into three classes, viz. :—

1. Rotary starching machines.
2. Machines for starching the different parts of shirts.
3. Machines for starching collars, cuffs, etc., with boiled starch.

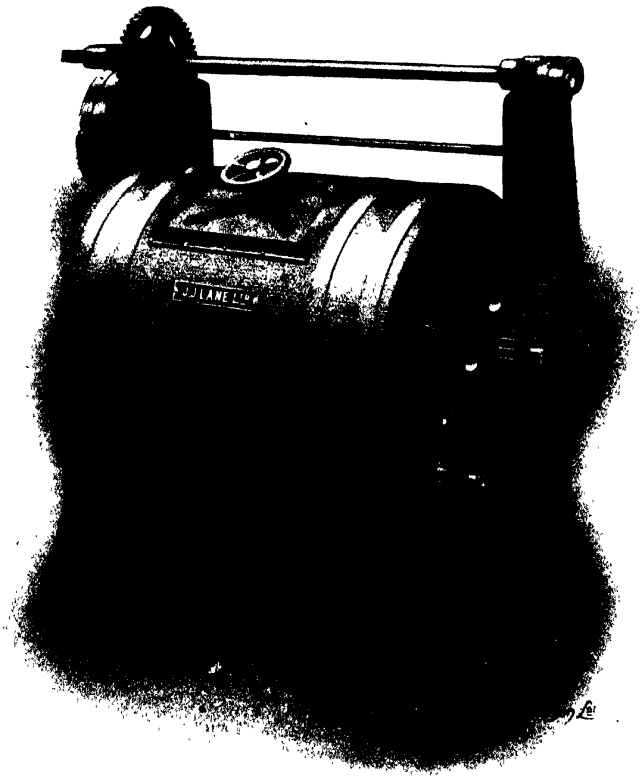


Fig. 46.—Barrel Starching Machine.

1. **Rotary Starching Machines.**—This class includes the "dip wheel starchers" which are largely used in Great Britain and Ireland. A typical representative is shown in Fig. 45. It

consists of a six-sided drum provided with a water-tight door. The drum is mounted on iron frames and is fitted with gear which causes it to revolve on its axis at a speed of about 20-30 revolutions per minute. The collars, cuffs, etc., are introduced into the machine along with the necessary amount of raw starch suspension, and the machine set in motion. Continual agitation is necessary in order that the goods may be thoroughly and evenly impregnated with the starch. The machine is run at a comparatively slow speed so that the goods drop twice from top to bottom during every revolution and are dashed into the starch mixture.

In some patterns the drum is barrel-shaped, while in others it is triangular or pentagonal. Fig. 46 illustrates one of the former class. It differs from many other machines in that it is fitted with a positive crank reversing gear, which defines exactly the amount of travel between each reverse of the barrel, whereas with the ordinary two belt driving gear, the barrel possesses a tendency to travel further one way than the other and may thus give rise to defective starching. In another machine of this class, (Fig. 47), the barrel is flat and the interior corrugated so that it exerts a rubbing action on the articles being starched. The barrel revolves on a trunnion fixed into suitable bearings at its base, and is so constructed that the motion takes place at an angle of about 45°. A power wringer may be fixed above the machine as shown in the illustdation.

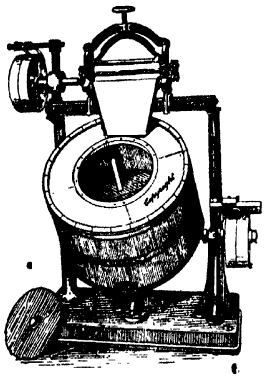


FIG. 47.—"SUNFLOWER" STARCHER WITH WRINGER.
(*Hill and Herbert, Ltd.*).

In use, the majority of rotary starching machines revolve in one direction only, since it is considered by many authorities that a reversing motion has little influence in facilitating the starching operation or on the degree of uniformity with which the starch

suspension is absorbed, while it is well known that renewals and repairs of the various parts are not so frequent as when reversing gear is employed.

The "*Elevator*" *Starching Machine*, (Fig. 48), resembles the ordinary type of rotary washing machine. Its chief distinguishing feature is the provision of gearing for the purpose of raising the inner perforated cylinder clear of the starch contained in the outer vessel whilst revolving, so that surplus starch can be drained off without passing through the goods. It is claimed by the makers, that, with this machine, there is not much danger of the latter becoming contaminated with "surface starch."

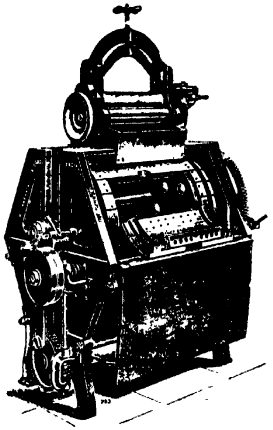


FIG. 48.—"ELEVATOR" STARCHING MACHINE.
(*W. Summerscales and Sons, Ltd.*).

The inner cylinder revolves on trunnions resting on strong frames and reverses after every few revolutions. It is fitted with projections on the outside for the purpose of agitating the starch, and several beaters are fixed to the inside. Ready access can be had to the machine by means of two doors, one at the front and the other at the back. The illustration shows the machine fitted with a wringer.

The foregoing machines are best adapted for starching goods with raw starch. If boiled starch is used, it is customary to employ a machine provided with a heating arrangement for keeping the starch paste at an elevated temperature during the starching operation. For the treatment of articles which need to be highly stiffened, machines are in use which automatically rub and force the hot starch paste into the goods.

2. **Machines for Starching Shirts.**—To the second class of starching machines belong those which have been specially designed for starching the bosoms, neck bands, and cuffs of shirts. One of the most useful machines of this class, (Fig. 49), consists of a tank for holding the starch mixture mounted on suitable supports and covered with two movable metal plates. In the interior of the tank are two series of brass or wooden rubbers fixed in a vertical position to frames of brass which move backwards and forwards when actuated by gearing. The part of the shirt to be starched is placed between the two sets of rubbers, and, as each set revolves in opposite directions by the friction set up, as well as backwards and forwards by the motion of the carrying

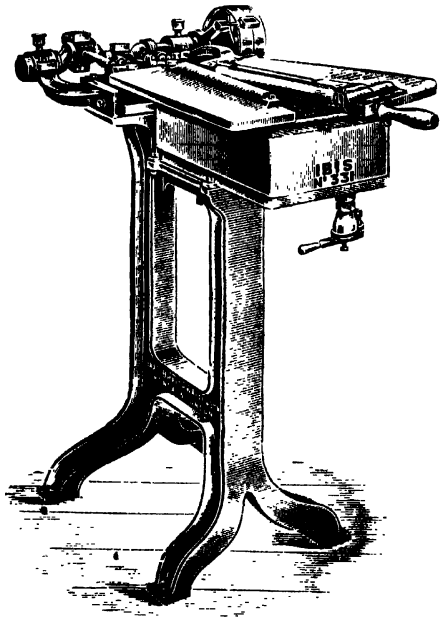


FIG. 49.—SHIRT STARCHING MACHINE.
(*I. Braithwaite and Son, Ltd.*).

frames, it will be evident that thorough impregnation of the "linen" is assured. The shirt is passed between two rubber rollers on entering the machine and these serve for the purpose of removing surplus starch after the operation is finished. By simply closing the cover, the machine is automatically set in motion. Similarly, the machine stops immediately on opening the cover.

In another form of this class of machine, the part of the shirt to be starched is pressed against a rubber-covered pad fitted in the interior of a small tank containing starch. By means of a rubber-covered plunger, which moves up and down, the starch is pressed into the shirt, and at the same time creases are removed by the smoothing action of the plunger. Excess of starch is removed in the same way as in the previous machine.

Similar machines to the above may be used for starching shirts with boiled starch, but in this case, it is customary to provide the starch tanks with steam jackets.

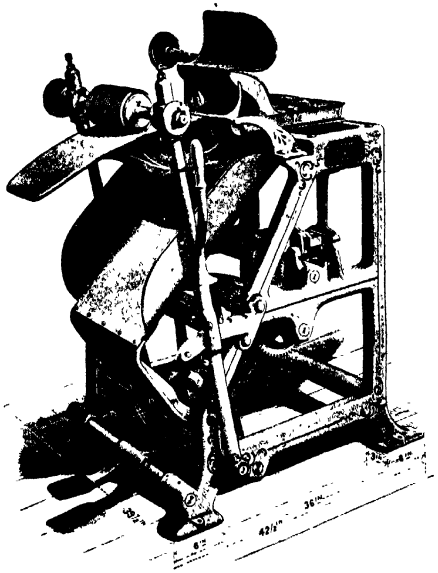


FIG. 50.—"BOSOM STARCHER."
(*J. Braithwaite and Son, Ltd.*).

Bosom Starching Machine.—A machine used for starching the bosoms of shirts is shown in Fig. 50. Its chief features are (*a*) a galvanized metal work holder of the size and shape of a shirt front; (*b*) a roller made of cellular rubber or fluted brass, supported by movable side arms; and (*c*) a brass starch trough.

While the shirt is being arranged on the plate, the roller is revolving in the starch trough, but by depressing the treadle at the front, it is lifted clear of the starch and caused to roll backwards and forwards over the bosom of the shirt on the plate. On

releasing the treadle, the roller travels back to the starch trough. The length of stroke can be regulated by means of a lever fixed to the side of the machine.

In this method of starching, it is evident that the starch is forced into the shirt by a rolling action and light pressure. Boiled starch is employed and the starch trough rests upon a steam chest, so that the contents can be kept hot.

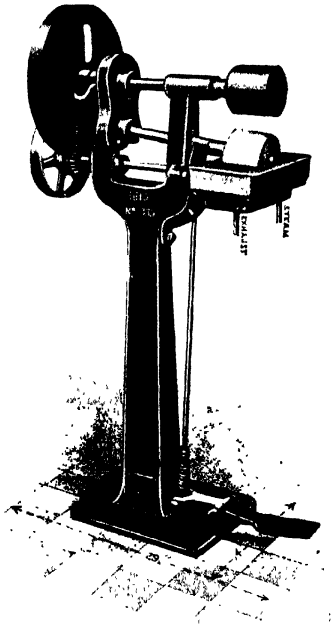


FIG. 51.—WRIST BAND STARCHER
(I. Braithwaite and Son, Ltd.).

Wrist and Neck-Band Starcher.—Fig. 51 illustrates a machine designed for starching the necks and wrist bands of shirts as well as attached cuffs. It is usually employed—in conjunction with the machine just described—in works where a large trade is done in the starching of shirts with boiled starch.

The machine is comparatively simple in construction; it consists essentially of a strong frame of iron supporting a brass starch pan resting on a steam heated arm, and arranged above this are two rollers and the necessary gearing. The lower roller

is covered with cellular rubber or fluted brass, and rests in the starch pan when the machine is not in use. The upper roller is of metal and the two are brought into contact, and separated, by depressing and releasing the treadle, motion being imparted by means of toothed wheels which are in connection with fast and loose pulleys.

3. **Machines for Starching Collars and Cuffs with Boiled Starch.**—The machines belonging to this class are wholly of American origin. They have been designed to impregnate small detached articles made of several thicknesses of cloth with a sufficient amount of starch—in a comparatively short period of time—to give satisfactory results in finishing. A well-known machine of this type is shown in Fig. 52. It consists of a cast-

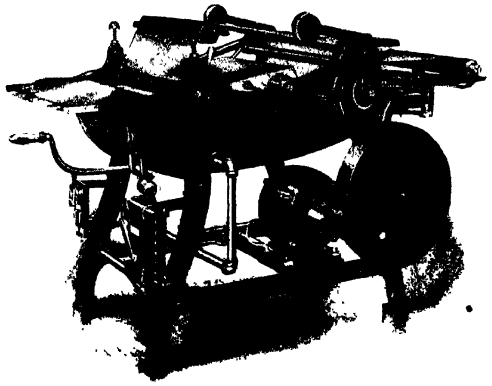


FIG. 52.—COLLAR AND CUFF STARCHING MACHINE. RUBBING BOARD TYPE. (*J. Armstrong and Co., Ltd.*).

iron stand supporting a starch trough lined with tinned copper. The trough is steam-jacketed, so that the starch may be kept at an elevated temperature during the starching operation. A live steam connection is also provided.

The goods are carried into the starch between open weave endless aprons, and are subjected to a rubbing action by means of corrugated rollers which press them against a perforated rubbing board. The rollers move alternately backwards and forwards while the goods are held quite flat between the aprons. At the exit end of the machine is a pair of stripping rollers which serve to remove surplus starch, the degree of pressure exerted being regulated by means of weights. The machine can be arranged either for belt gear or attached motor.

After passing between the stripping rollers, the goods are laid out flat on a suitable table and "wiped down" in the usual way. They are then ready to be dried.

In another type of continuous starching machine, a large brass drum covered with wool felt and cotton cloth, takes the place of the rubbing board used in the machine described above. The lower half of the drum is immersed in starch paste contained in a steam-jacketed starch trough, and is in constant touch with a series of brass rolls, which are held in a brass frame of semicircular shape. When the

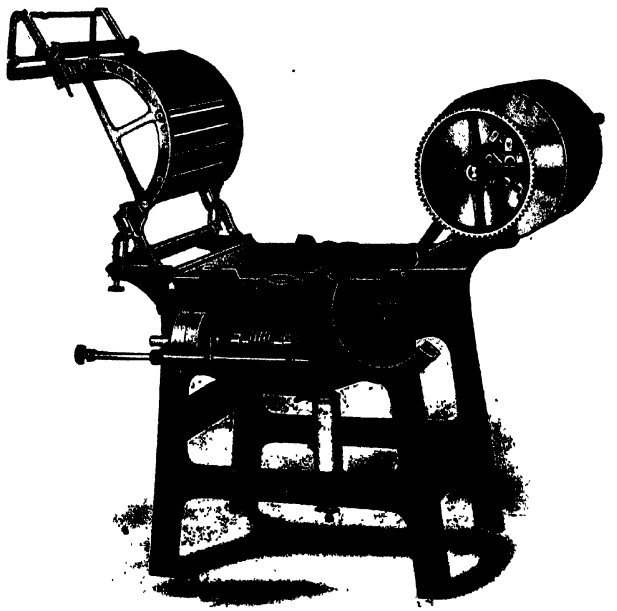


FIG. 53.—COLLAR AND CUFF STARCHER. DRUM TYPE. OPEN.
(*J. Braithwaite and Son, Ltd.*).

machine is in use, the collars are fed between the corrugated rolls, and the padded brass drum, and, by means of the pressure applied, —which is governed by adjustable springs—absorb the necessary amount of starch. The collars are carried from the starch pan to the wiping table on an endless apron, and a series of string guides

placed round the padded drum strip the articles from it as they come out of the starch trough. Fig. 53, shows the machine open for cleaning.

A modified form of the above apparatus is built with two drums and two series of corrugated rolls, so that the goods remain for a longer time in contact with the starch and rubbing surfaces than in the single drum machine Consequently, a more thorough and uniform penetration of the goods by the starch is assured.

SECTION IV.—DRYING APPARATUS.

The drying systems in use in modern steam laundries are:—

1. Drying rooms in which the goods are stationary, the air being heated by radiation from coils of steam pipes, while circulation is effected by natural means or aided by the use of fans.
2. Drying rooms as in No. 1; a warm air blast being supplied by means of a fan for heating purposes and for ensuring the removal of moisture laden air.
3. Conveyor drying rooms in which the air is heated by steam coils or introduced as in No. 2, the articles being conveyed automatically in and out of the room.

A tumbler drying room has also been lately introduced for separating and drying certain classes of articles direct from the hydro-extractor. This is illustrated and described in Part II.

1. **Drying Rooms with Natural or Induced Air Circulation.**—The simplest form of drying apparatus consists of a suitable room, on the floor of which is arranged a series of steam pipes heated either by exhaust or live steam. One or more outlets in the ceiling serve for the escape of moist air, while openings near the floor level allow the ingress of fresh air. Circulation is brought about by the difference in the densities of the warm and cold air. As the temperature of the air in the vicinity of the steam pipes rises, expansion takes place and the light warm air ascends to the outlet, taking up moisture from the goods in its passage. In this system, drying takes place unevenly for the following reasons:—In the first place, the warm air takes the shortest direction to the outlet, so that some goods may be subjected to its action to a greater extent than others; secondly, the quantity of water evaporated in a given time is not always the same owing to variations in the condition of the atmosphere; and in the third place, the temperature of the warm air is lowered on coming into contact with the wet goods. Hence, it exhibits a tendency to

descend, and coming into contact with other wet goods retards vapourisation of the water they contain. The greater the difference between the outside and inside temperatures, the more efficient is the drying operation, but in any case a considerable waste of heat occurs. Collars, cuffs, etc., which have been starched with boiled starch are commonly dried by means of a system of this kind working at an elevated temperature, and, under such conditions, very satisfactory results are obtained. A typical drying room in which the circulation is effected in the manner described above is illustrated in Fig. 54. As will be seen by a glance at the

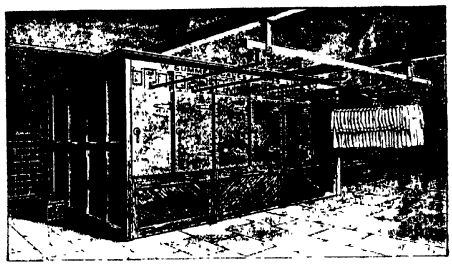


FIG. 54.—DRYING OVEN.
(*W. Summerscales and Sons, Ltd.*).

illustration, the goods travel in and out of the room on overhead tracks, the openings being provided with iron doors.

In most forms of drying apparatus working on this principle, it is customary to assist the natural circulation of the air by means of one or more propellers or exhaust fans placed on top of the drying room. When exhaust fans are used, drying takes place more rapidly owing to the reduction in the pressure of the air and the more rapid removal of aqueous vapour. Just as in the previous case, however, it is difficult to ensure uniformity in drying, for the fan will draw its supply from the nearest inlet, so that the current of air may only come into contact with a portion of the goods. Furthermore, the fan may be so powerful as to prevent the air from remaining for a sufficient length of time in contact with the steam pipes, to enable it to acquire the necessary heat for readily vapourising moisture. For these reasons, it is now the general practice to use propellers, so that the air is forced down through the goods and then passes out through openings in the apparatus just above the floor level. Drying rooms of this kind are almost universally employed for drying certain classes of goods at high temperatures; they appear to have been specially introduced for use in connection with the boiled starch pro-

cess, and, like many other machines of American design, they are commonly built on the sectional or compartment principle. Hence, their usefulness for a small trade will be apparent, while additional compartments can be added as the work increases. A typical one compartment drying room designed on this principle is shown in Fig. 55. It is built of wood, in sections, which bolt together. The interior is lined with asbestos to prevent waste of heat by transmission and to minimise the risk of fire. On top of the asbestos is a lining of heavy tin plate which is stated to be far

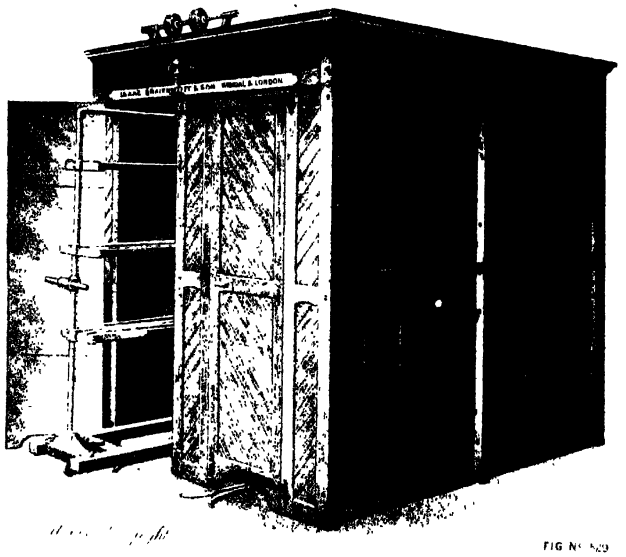


FIG. 55.—TRUCK COMPARTMENT DRY ROOM.
(*I. Braithwaite and Son, Ltd.*).

superior to galvanized iron, as it does not buckle when exposed to heat, neither does it readily corrode or become coated with a grimy deposit.

A section provided with two doors and with space for two trucks is termed a compartment. The trucks run on angle iron tracks, and are made entirely of metal. They are fitted with galvanized iron carrier bars for supporting the articles to be dried, and also with handles and roller bearing castors for readily moving them about.

Heat is supplied by coils of steam pipes, of which there are three to each section or compartment, viz. :—One coil extending the length of each side and another down the centre. Each coil is made up in sections with return bends so as to be complete in itself.

The fan for circulating the air is placed on top of the room and is driven by means of belt gearing.

Special collar and cuff carrier bars are generally used with this apparatus. They are made of galvanized iron and are triangular in shape. Hooks are placed on each side of the bar, each pair being formed from one piece of wire. Consequently, it is practically impossible for a hook to drop off. Plain carrier bars are also furnished for supporting miscellaneous articles.

The system of drying described above is specially adapted for boiled starch work; it is not suitable for woollens or for the general work of the laundry owing to the high temperature at which drying takes place. Hence in domestic laundries in which boiled starch is used for collars, cuffs, etc., it is necessary to employ two drying rooms, in one of which, woollen and other goods can be dried at a medium temperature.

2. **Drying by Means of a Warm Air Blast.**—The most satisfactory system of drying the various articles treated in the laundry, excluding those goods which have been heavily starched with boiled starch, is dependent on the use of a current of warm air, which is blown into the drying room by means of a propeller or fan. This system has been largely adopted in modern laundries and gives excellent results, while when properly designed it is considered to be the most economical of all processes of drying textile materials. The principal features are as follows :—

1. A suitable room into which the warm air is discharged.
2. Trucks or other apparatus for supporting the goods to be dried.
3. A heater and blower for heating and supplying the air.
4. Ducts for distributing the air currents.
5. Exhaust openings for the escape of air which has done its work.

Drying Rooms.—These are usually built of brick. If of wood or iron they should be insulated to prevent loss of heat by transmission. In one system two rooms are employed, the warm air inlet being so arranged that by moving a swing door the air is directed into either room as desired. When this method is adopted the goods are dried in one of the rooms while the other is being emptied and re-filled, and so on alternately. An arrangement of this kind is shown in Fig. 56. The apparatus for heating

and discharging the air is placed on top of the rooms, and communicates with a vertical duct which branches near the floor level into two horizontal ducts, one for each room. By moving the

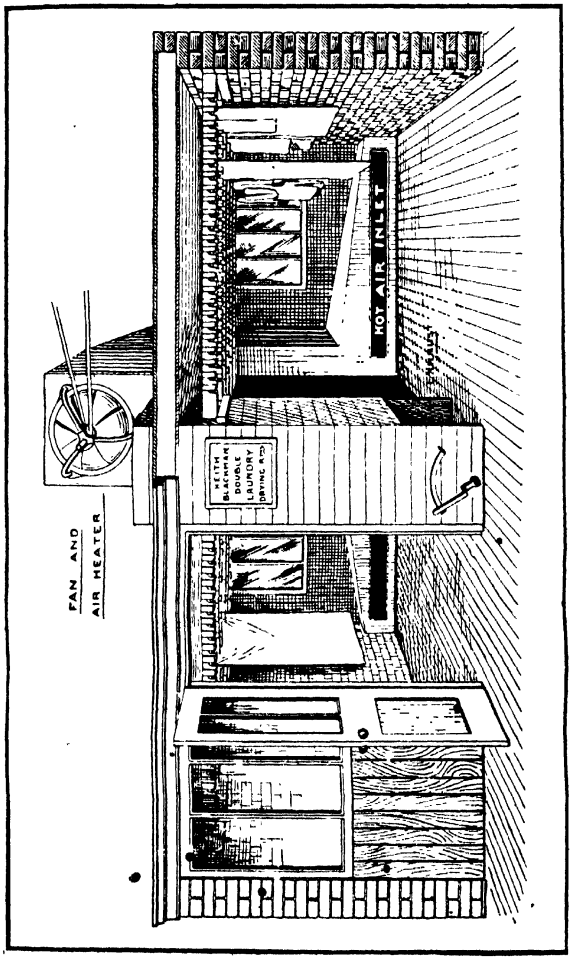


FIG. 56.—TWIN DRYING ROOMS. FRONT VIEW AND SECTIONAL ELEVATION.
(J. Keith and Blackman Co., Ltd.).

handle at the front of the rooms, the air current can be directed to the left or right according to requirements, while the moist air escapes through the outlets in the central partition.

The type of drying room which appears to be coming into general use is designed on the draw-out system, a brief description of which has already been given. In this, the outer casing is built up in sections, and each section is provided with a door or panel which consists essentially of one end of a truck or "horse," which runs on rails placed overhead or laid on the floor. The other end of each "horse," *i.e.*, the back, also acts as a door, so that when the "horse" is withdrawn to its fullest extent, the opening into the drying room is re-sealed; thus, waste of heat and interference with the direction of the air currents are avoided. In some cases, however, the "horses" are made interchangeable, and can be entirely withdrawn. Hence this arrangement enables trucks to be loaded while all the sections are in use, and when one "horse" is removed from the room, another is ready to be introduced. Many other variations may be adopted.

Supports for the Goods.—These consist of fixed or movable wooden or galvanized iron rods or racks which are attached to supports in the ceiling, in the case of drying rooms in which the operators have to enter, while in the draw-out system they are built up in the form of sliding trucks or "horses" as previously described.

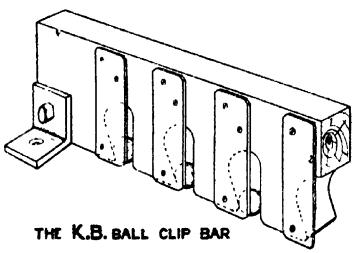
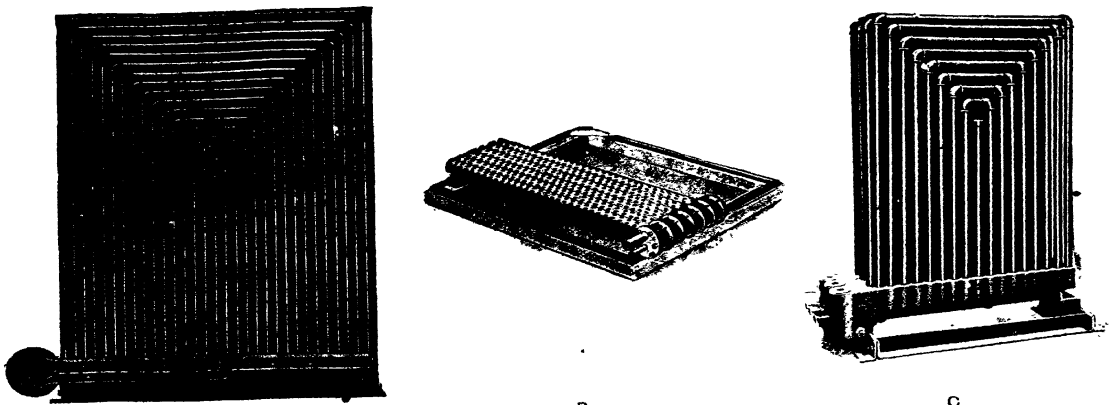


FIG. 57.—BALL CLIP BAR.
(J. Keith and Blackman Co., Ltd.).

Ball clip bars (Fig. 57), are used in the system illustrated in Fig. 56. These are wooden bars provided with notches at regular intervals along their entire length. In each notch is one or more balls which can be pushed back into a comparatively large groove, thus enabling the goods to be readily clipped or removed as required.

Air Heaters and Blowers.—For heating the air, coils of steam pipes are employed enclosed by a sheet steel casing. The pipes are heated either by exhaust or live steam and are assembled together in various forms. In one well-known type, the heater is built up in sections, each of which contains either two or four



A. B. C.

FIG. 53.—"SECTIONAL BASE" AIR HEATER. (A) SECTION. (B) ASSEMBLED SECTIONS. (C) INDEPENDENT SECTIONS.
(Sturtevant Engineering Co., Ltd.).

rows of vertical steam pipes connected by horizontal pipes at the top (Fig. 58, A and B). Both sides of the sections rest on angle irons which allow the bases to expand and contract freely. In order to economise room and material, the sides of the sections are corrugated so that they fit each other closely. On the end of each section is a flanged head divided by a horizontal diaphragm, the upper part communicating with the steam supply and the lower with the drain. A blank flange is placed at one end of a series of sections and the steam inlet and drain outlet pipes at the other. When desired, a series of sections can be constructed with independent steam and drain connections to each section, thus allowing the amount of heating surface to be varied at will. This arrangement is represented in Fig. 58C.

The air is heated by drawing or blowing it into the steel encased heater by means of a fan. It is next brought into close contact with the steam pipes and then passes through suitable ducts into the drying room. Opinions differ as to whether the air should be drawn or blown through the heater. In either case, however, it expands on coming in contact with the hot pipes; hence, more power is required to handle the increased volume if the exhaustion process is adopted, with the result that the heated air is supplied to the room under greater pressure than when the second method is employed. Thus, drying takes place more rapidly owing to the greater ease with which the fibres of the articles are penetrated by the air current. The fan or blower is of the centrifugal type partly enclosed by a steel casing so as to ensure a steady blast. If it is to be used for exhausting, there is only one inlet which is connected to the distributing duct, whereas when required for blowing, an inlet is usually left on each side in order that a sufficient supply of air may be obtained.

Ducts.—If the drying room is large or is built on the sectional system with a considerable number of "horses" in one room, it is necessary to provide means for the equal distribution of the heated air. This is effected by the use of ducts or distributors which are made of galvanized sheet steel piping with suitable outlets for the air. Each outlet is fitted with a regulating slide so that air can be admitted into the room in the immediate vicinity of each or all of the "horses" as required. Ducts also serve for the purpose of regulating the temperature of the air currents. Thus by the use of a cold air by-pass and two ducts, with a mixing damper, either cold or hot air only, can be admitted into the drying room, while a mixture of the two in any proportion can also be obtained.

In some cases underground ducts are used, the heating apparatus, etc., being placed on the ground level near one side of the room, and the hot air admitted from a short underground

Outlets.—Considerable diversity of opinion still exists respecting the best positions for the outlets as well as the inelts of drying rooms, although many authorities are agreed that the most efficient

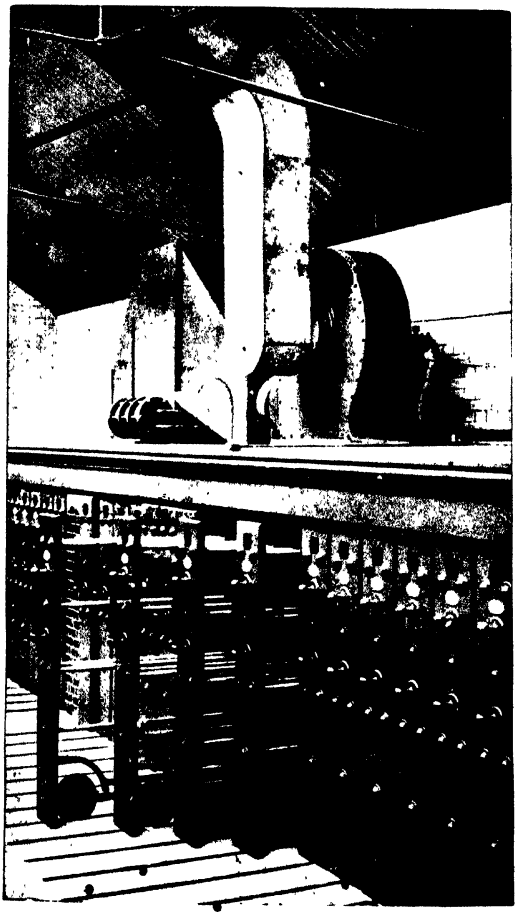


Fig. 59.—Sectional Drying Room with Fan and Air Heater.

(*Sturtevant Engineering Co., Ltd.*).

drying system is one in which the heated air enters at the top of the room and subsequently escapes through outlets at or near

the floor level. This arrangement is now generally employed. In many cases the outlets are made in the floor of the room and communicate with an underground flue leading to the chimney.

When the hot air is admitted from an underground duct, the moist air makes its exit through a similar duct on the other side of the room. A typical sectional dry-room with fan and heater is shown in Fig. 59. In this apparatus, the air is supplied to the heater through a connecting pipe which is in communication with the atmosphere outside the building. This pipe, however, is frequently dispensed with, and the air drawn naturally from an air duct built in the wall, against which the apparatus is fixed.

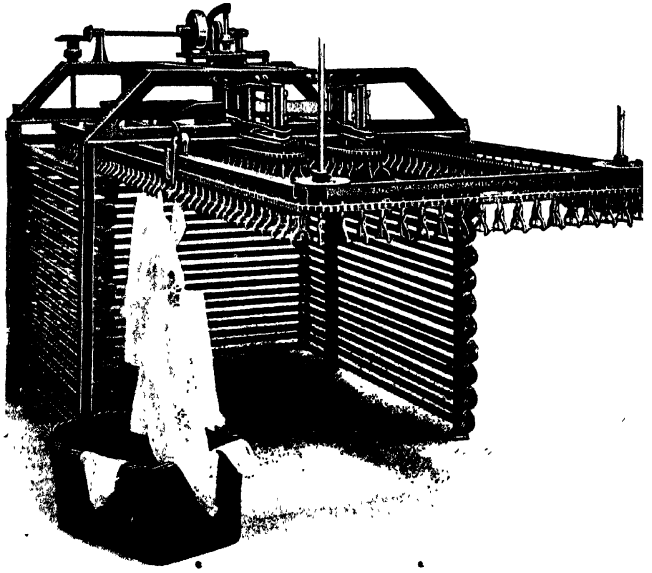


FIG. 60.—FRAMEWORK OF CONVEYOR DRY ROOM.

(J. Braithwaite and Son, Ltd.).

In some works, an additional room is built on top of the main drying rooms so as to enclose the heater and blower used for supplying hot air to the chamber beneath. The room is thus heated by radiation from the air heater, and is very serviceable for drying miscellaneous articles and woollens. A door of the ordinary type is provided which is reached from the ground floor by means of steps. "Horses" cannot, of course, be used.

3. **Conveyor Dry Rooms.**—In this system of drying, the goods are slowly conveyed on endless chains or conveyors, through suitable rooms which are heated either by steam pipes or by means of a warm air blast. Two well-known types of drying rooms working on this principle are in general use, one of which is chiefly employed in conjunction with the boiled starch process while the other is available for the general work of the laundry. Fig. 60 illustrates a conveyor dry room apparatus built by the American Laundry Machinery Co. It consists essentially of a cast-iron frame supporting the conveyor chain, track, driving mechanism, and two or more series of steam coils, the whole being enclosed in a wooden or galvanized iron case (not shown in the illustration). The chain is of tinned iron and the trolleys which carry it along the track are fitted with roller bearings. Fig. 61 illustrates the automatic unloading mechanism as

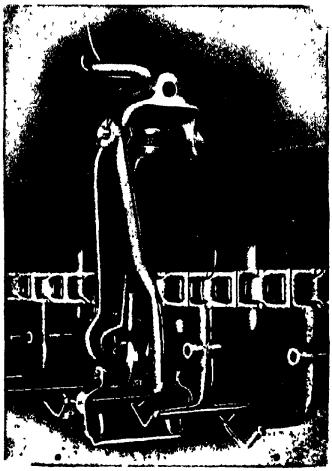


FIG. 61.—AUTOMATIC UNLOADING MECHANISM.

(I. Braithwaite and Son, Ltd.).

used for collars and cuffs; its mode of action being clearly shown. Different lots of goods can be kept separate by placing a brass pin into the sleeve of the hanger at the end of each lot. This makes the circuit of the room, and when the last piece of the lot has been unloaded, the pin strikes the long projecting forks, and the chain is automatically stopped. This type of dry room is best suited for drying collars, cuffs, and shirts which have been

starched with boiled starch, but it can be modified so as to serve for drying other goods, in which case specially designed loading and unloading mechanism is employed. The driving gear is

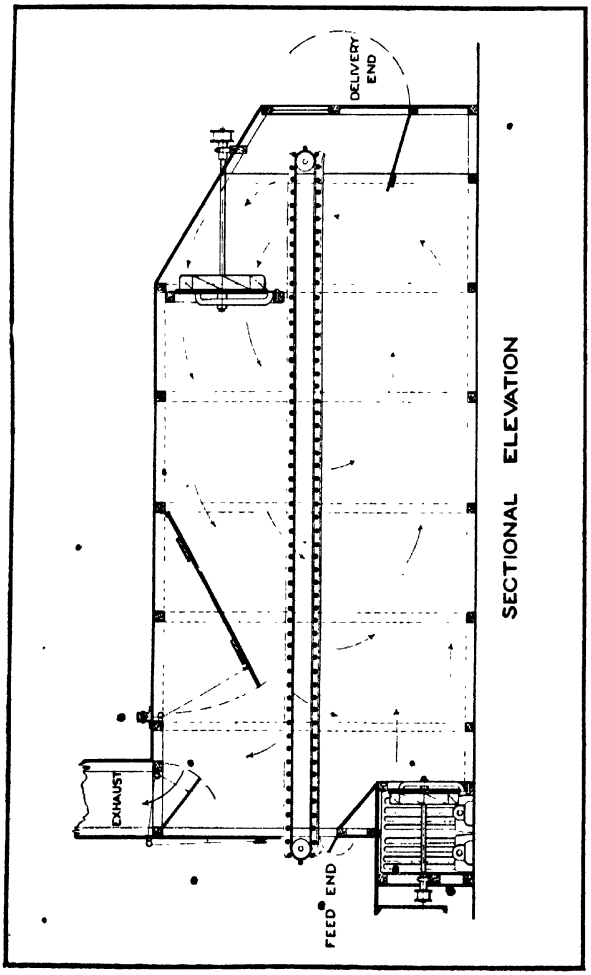


FIG. 62.—CONVEYOR DRY ROOM. SECTIONAL ELEVATION.
J. Keith and Blackman Co., Ltd.

placed on the roof, one belt driving the chain as well as a fan for circulating the air. The arrangement of the chain within the

room depends upon the size. In the smallest size of room, the chain is arranged in two loops, while in the larger rooms, four and six loop arrangements are in general use. In some cases combination truck and conveyor dry rooms are used.

Fig. 62 is a sectional elevation of a conveyor dry room belonging to the second class. In this apparatus, the goods are conveyed through the room by means of a double endless chain working in sprocket wheels at both ends. Attached to the chain are round wooden bars provided with special clips, from which the goods are suspended. The chain is enclosed in a wooden case built with double walls, and is placed in such a position that there is ample space both above and below for the circulation of air currents. A fan draws air over a heater and delivers it into the lower space, while another fan in the upper space at the other end of the room takes up the air from the

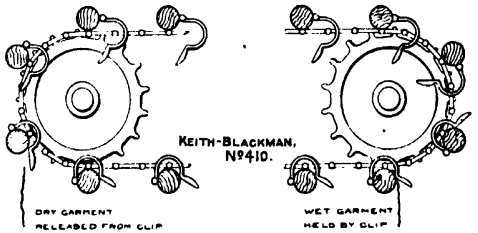


FIG. 63.—AUTOMATIC CLIPS.

lower space and propels part of it downwards, while the remainder passes through the outlet into the atmosphere. The articles to be dried are placed one at a time against a round bar, with an upward movement, the clips automatically rising and falling, thus clipping the goods in position. Each bar is capable of holding four shirts or other articles in proportion. After filling two or three bars, the operator turns a small wheel in order to move the travelling chains forward, thereby bringing other bars into position. The operation is repeated until all the rods are full, by which time the articles first put in have arrived at the delivery end. At this stage, for each bar loaded at the feed end, one bar is automatically unloaded at the delivery end, and the goods fall on a grid ready for collection. Fig. 63 shows the automatic clips in action.

SECTION V.—IRONING AND FINISHING MACHINERY.

The machines used in the various ironing and auxiliary operations carried on in the laundry may be conveniently arranged in three groups, viz. :—

1. Steam ironing machines, including multiple roller machines.
2. Shirt, collar, and cuff ironing and finishing machines.
3. Ironing machines for body linen, blouses, and similar articles.

Miscellaneous appliances will be described when dealing with the finishing operations in which they are employed.

1. **Steam Ironing Machines.**—The single roller steam ironing machine or calender, generally known as a "decoudun," is one of the most important machines used in the laundry. It is extensively employed for ironing all classes of single ply flat articles, and is especially adapted for the purpose of imparting a a gloss to partially dry flat goods which have been previously impregnated with a small quantity of starch. The machine derives its popular name of "decoudun" from its originator, who was a French engineer.

A decoudun of modern construction is shown in Fig. 64. It consists of a cast iron roller—turned perfectly true—which revolves in a cast iron concave bed, machined out to fit the circumference of the roller when the latter is covered with felt. The bed is highly polished and both it and the roller can be heated by steam, the former being capable of withstanding a pressure of about 80 lbs. per square inch and the latter a pressure of not more than 20 lbs. As a rule, however, the working pressure on the bed varies from about 40-50 lbs. per sq. inch. The roller is supported at each end in sliding bearings which are mounted in cast iron frames; it is provided with power raising gear with automatic stops at the top and bottom, so that it can be raised clear of the bed when not in use, or for cleaning, etc. The pressure on the bed can be readily adjusted by slightly lowering or raising the roller, a hand wheel attachment being provided for the purpose.

The roller is driven at both ends by means of spur and pinion gear operated by a countershaft at one end of the machine through worm gearing, and can be driven at two different speeds.

Decoudun rollers are made in various sizes; the width varies from 50 to 120 inches, and the diameter from 18 to 36 inches. The 108 by 24 inch machine is largely used, although many launderers favour the 120 inch machine. A covering of woollen material technically known as "felt" or "blanketing," is wound round the roller before use. This acts as an elastic cushion, thus preventing the goods from

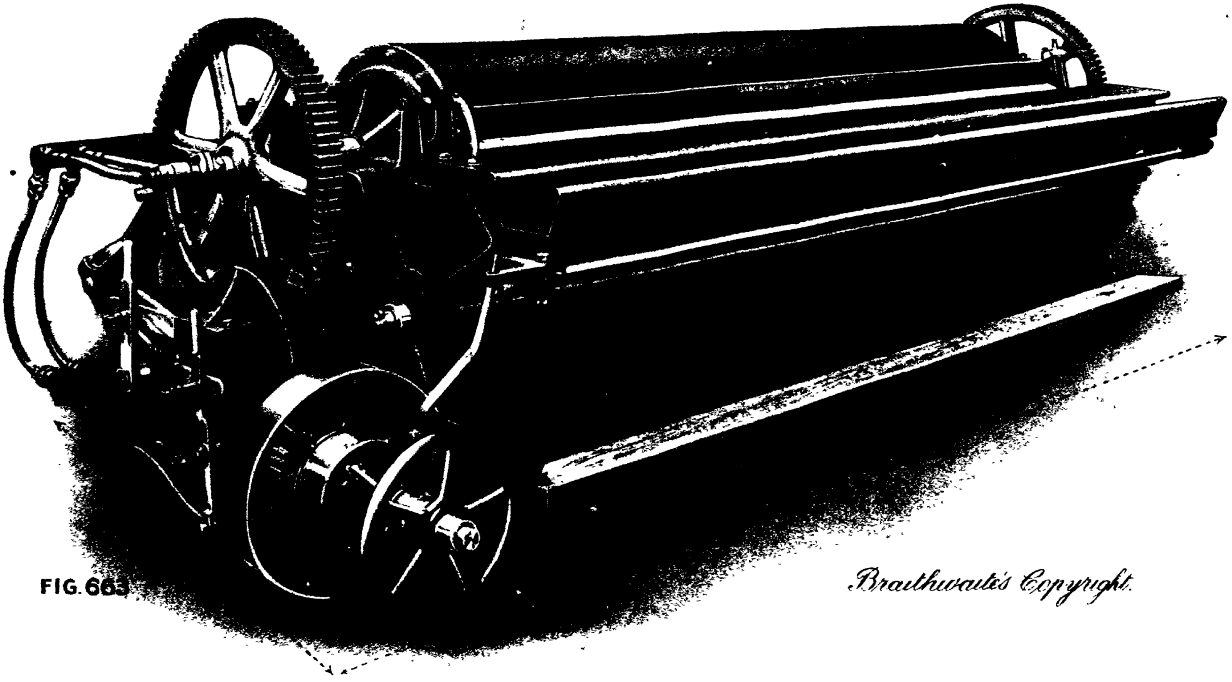


FIG. 64.—"IBIS" DECOUDUN. (*I. Braithwaite and Son, Ltd.*).

being subjected to an excessive amount of friction when in contact with the metal bed, while its property of readily absorbing moisture is of great importance in facilitating the ironing operation. The "felt" employed for the purpose is obtainable in a great many qualities both as regards thickness and nature of fibres from which it has been made. Too much attention cannot be paid to the proper covering of decouduns, and, in fact, all ironing machines, because satisfactory work cannot be done even with the aid of the most expensive machines, if the covering is of inferior quality or if the rollers are clothed in a careless manner. One method of covering the roller with "felt" of medium thickness, is to attach a piece of calico (about one round) with a little starch paste and to put one end of "felt" under loose end of calico or stitch together. The "felt" is then wound on to the roller according to thickness required. Finally a few layers of cotton sheeting are wound on top in order to protect the "felt" from excessive wear and tear. It is customary to remove and wash the sheeting after every few days' work. When thick "felt" is employed, it is passed once round the roller and the ends sewn with silk thread in such a way as to render the seam quite smooth after the roller has been in use for a short time. This method is now seldom used. The chief point to be observed in all cases, is to make sure that a uniform layer of elastic and absorbent material of sufficient thickness to admit of considerable pressure without much sacrifice of its properties, is presented to the polished surface of the heated bed.

A finger guard is fitted in front of the machine as well as a feed lip, the latter being used for the purpose of guiding the goods into the machine. For high speed work, a ribbon continuous feed device is often used. This consists of a series of endless narrow cotton bands upon which the goods are laid and thereby carried automatically into the machine. Several operators can thus serve the machine independent of one another, since there is no feed lip to operate.

When using a decoudun, a considerable amount of steam is generated from the articles being ironed, and in order to facilitate its escape, the exit sides of the beds of many machines are made to curve outwards.

The roller is heated by steam at a pressure of about 10 lbs. per sq. inch, this being generally sufficient to keep the covering in good condition, as excess of moisture is evaporated during the time that the roller is out of contact with the bed. It is evident, however, that the amount of moisture retained by the "felt" depends upon the nature of the latter, the speed of the machine, and the condition of the articles passing through. If the covering retains too much moisture, the goods cannot be properly finished.

Steam traps are provided for all ironing machines heated by steam, while reducing and safety valves are fitted when the steam pressure required is lower than that in the boiler.

Multiple Roller Ironing Machines.—We have previously mentioned that single roller ironing machines, *i.e.*, decouduns, are chiefly adapted for finishing goods which have already been partially dried. Articles taken direct from the hydro-extractor usually require two passages through one of these machines in order to obtain satisfactory results. On this account, it is the custom in some works, to employ two decouduns, one of which is used to remove excess of moisture from the goods, and the other for the final finishing operation. In such cases, the decoudun used for drying purposes should have a larger area of heated surface than the finishing machine. By adopting this plan, less strain is put on the latter; the felt is easily kept dry, and the "finish" obtained is more satisfactory and uniform. The process is too slow, however, in laundries carrying on a large trade in the cleansing of flat goods, so that machine makers have introduced various types of multiple roller machines, each of which is capable of a very large output. Unfortunately, these possess certain disadvantages which militate against their general adoption for all classes of flat work.

Multiple roller machines are invaluable for rapidly drying flat articles, such as hotel and restaurant work, at one operation; they also impart a slight "finish" to the goods, but cannot be used, to any great extent, for ironing starched goods, as the latter stick to the first roller and tend to wind round it. Guiding tapes have been introduced to overcome this defect, but these frequently leave string marks on the goods, and the difficulties associated with sticking have not been completely overcome.

The speed at which articles can be dried and finished on a machine of this kind, depends upon their thickness, the amount of moisture present, the area of the heated surfaces of the machine, and the skill of the operators in introducing the goods. The highest speed is about 60 feet per minute.

Multiple roller machines are largely used in America, and to a considerable extent in this country and other parts of Europe. They may be divided into the following classes:—

1. Machines fitted with from 2 to 8 padded rollers, which fit into a corresponding number of stationary steam heated "beds."
2. Machines provided with one or two steam heated rollers, and a number of smaller padded rollers which are not heated.
3. Machines possessing both steam heated rollers and steam heated chests or "beds."

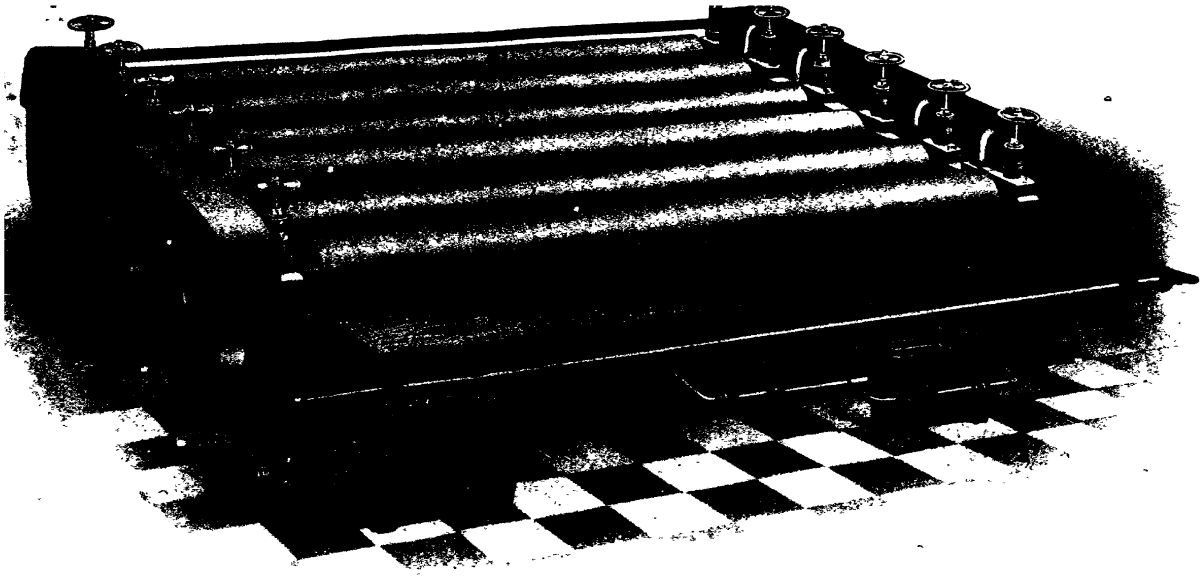


FIG. 65.—SIX ROLL IRONER. (*D. and J. Tullis, Ltd.*).

To the first class belong several well-known machines fitted with two, three, or more rollers, each of which revolves in a steam heated polished concave bed. A six roller machine of this type is shown in Fig. 65. The beds are arranged in such a way, that there is a gradual slope from the feeding end, so that the goods pass automatically from one bed to another. The rollers are made of cast-iron, polished on the faces, and open at the ends. They are covered with felt, and the pressure is regulated by small hand-wheels and screws which enable them to be raised and adjusted separately. Special gear can be fitted for lifting the whole of the rollers clear of the bed simultaneously. This arrangement is said to be of considerable importance, because, apart from a saving in time, the roller coverings last longer if they are immediately raised out of contact with the beds when the machine is stopped for a short time.

In another machine of the same class (Fig. 66), there are five steam heated beds, each of which is shaped to receive a padded roller. Four of the beds are placed immediately underneath the corresponding rollers, while the fifth is inverted so that its cor-

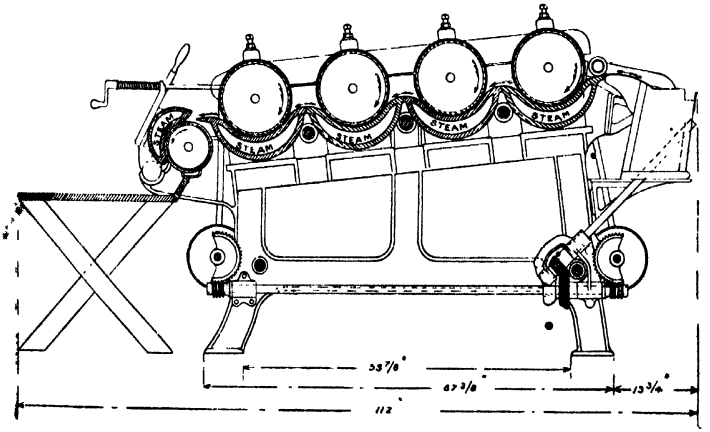


FIG. 66.—FIVE-ROLL IRONER. SECTION.
(*I. Braithwaite and Son, Ltd.*).

responding roller is placed underneath. The object of this arrangement is to enable flat goods to be ironed on both sides by one passage through the machine. The rollers can be raised clear of the bed by means of a lever, and as in most machines of this type they are placed at suitable distances apart in order to facilitate the escape of vapour produced by the contact of moist articles

with the heated beds. Different speeds are readily attainable by the use of a countershaft and suitable pulleys, thus enabling the operators to vary the speed of the machine according to the nature of the goods which are being ironed. The total heating surface is 8,400 sq. inches, and the area under pressure of the rollers is 5,100 sq. inches.

In some machines of this type, the inverted bed is replaced by a small steam heated uncovered roller.

It will be evident from our description of the above machines, that a portion only of the heated beds is actually utilised for drying and finishing purposes, and machine makers have long recognised that a more economical system would be one in which the whole of the heated surface could be rendered available for such purposes.

At the present time there are several machines on the market embodying this principle, and these are capable of drying and ironing flat goods as fast as they can be fed into the machines. The constructional details are almost identical with those of the machine described above. A distinguishing feature, however, is the provision of an endless travelling band or apron, upon which, the goods are carried beneath and in close contact with the heated beds. The latter are polished underneath as well as above, and the available heating surface is about twice as great as that provided by a machine of similar size built on the usual plan.

American machine makers have paid considerable attention to the building of ironing machines on the principles outlined above, and an interesting development is the introduction of machines designed on the sectional or unit system. Thus, a machine which is only suitable for a small output can be readily converted into a large capacity machine by the addition of sections or units as occasion demands.

Fig. 67 shows a section of a three roll sectional ironer which is the simplest form of this type of machine. Its essential features are three padded rollers A, and three steam heated chests B, supported by a strong framework. The chests are covered on the underside with asbestos to prevent loss of heat by radiation. Two of the rolls are 14 inches in diameter and fit into corresponding steam chests, while the last chest is inverted over a roller 10 inches in diameter. To this section or unit, other sections of one or two rolls each, and a similar number of chests, may be added from time to time. In order to prevent the sections from getting out of alignment, they are so bolted together, as to make it impossible for them to work loose. The rolls are hollow and have open ends, a feature that considerably diminishes the risk of burning the coverings. They are also fitted with an automatic pres-

sure device which enables the rolls to be raised in battery by simply lifting a lever connected to the driving gear of the machine.

The feeding device is of the ribbon type and is furnished with an automatic safety finger guard. Fig. 68 shows a sectional view of a 5-roll ironer built up of two sections, viz. :—A 3-roll ironer as described above, with a unit of two rolls and chests added.

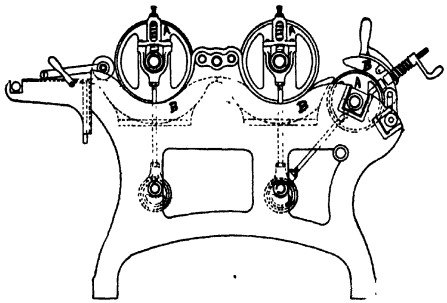


FIG. 67.—THREE ROLL SECTIONAL IRONER. SECTION.
(*J. Braithwaite and Son, Ltd.*).

To the second class of multiple roller machines belong the cylinder steam "mangles," which are largely used in America and to a considerable extent on the Continent. The main features of a machine of this type are (*a*) a cylinder heated by high pressure steam, and (*b*) a number of small padded rollers mounted in con-

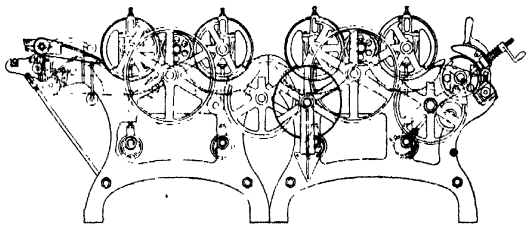


FIG. 68.—FIVE-ROLL IRONER. SECTION.
(*J. Braithwaite and Son, Ltd.*).

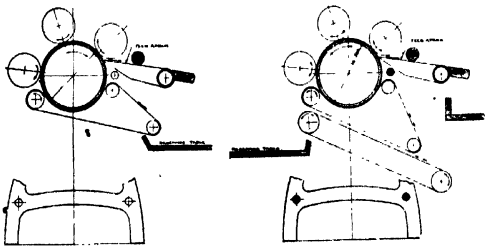
tact with the periphery of the heated roller. The cylinder is caused to revolve by means of suitable gearing, which also actuates the padded rollers. A single or double apron attachment (Fig. 69) is provided for the purpose of guiding the goods out of the machine, the latter removing them on the feeding side and the former on the opposite side. Tapes are also provided to prevent the goods from winding round the padded rolls. The number

of the latter varies from 3 to about 8, and the diameter of the cylinder from 16 to 24 inches.

One form of this class of machine is now made with two heated cylinders, one of which is about 24 inches and the other 8 inches in diameter. Five padded rollers are provided, and the arrangement of these, in conjunction with the heated cylinders, enables the goods to be dried and polished on both sides by one passage. The apron arrangement of a very large capacity machine belonging to this class is shown in Fig. 70. The chief features of the machine may be briefly summarised as follows :—

1. The steam heated cylinder is 120 inches wide and 48 inches in diameter.

2. Six padded rolls are mounted round the periphery of the cylinder, each roll being covered with eight inches more felt than the preceding one, so as to keep the goods taut without tearing the most delicate articles. The gear of the rolls is in mesh with the main driving wheel.



Single Apron. Double Apron

FIG. 69.—LOWER APRON ATTACHMENTS.
(*J. Armstrong and Co., Ltd.*).

3. The heated cylinder travels faster than the rolls, aprons, or goods, in order to (*a*) obtain a good "finish"; (*b*) to reduce the amount of wear and tear to which the roll coverings are subjected and to keep them in a comparatively soft condition, because in cases where the rolls travel faster than the cylinder, the coverings are continually winding tighter on the rolls; and (*c*) to lengthen the life of the aprons. When the latter travel faster than the cylinder, they are being continually pulled by their driving rolls, but in this machine they are assisted in their travel by the motion of the cylinder.

4. An automatic device is provided for raising and lowering the rolls, the aprons being slackened or tightened at the same time, while for recovering purposes, etc., the rolls may be readily thrown out of gear with the main driving gear by turning a hand wheel.

6. The goods are fed into the machine by means of an automatic apron "feed" and pass over and around the cylinder. At apron roll No. 10, they are taken up by the inside apron and carried by it against the cylinder to roll No. 2. Here the goods are taken between the outer and inner aprons and carried back under the machine to the delivery table. This arrangement gives the articles a contact against the cylinder of 7/8ths of its surface, and the additional drying effect of another passage beneath the cylinder.

7. The string guides are counter-balanced to keep the strings taut, and are arranged to prevent string marks, while automatic guides keep the aprons in position.

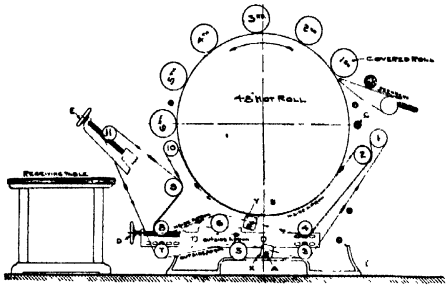


FIG. 70.—APRON ARRANGEMENT OF "TROJAN" MANGLE.
(*J. Armstrong and Co., Ltd.*).

It is claimed that this machine will dry and iron goods as fast as they can be handled by the operators.

Multiple ironing machines of the third class possess the chief features of steam chest machines, as well as those of steam mangles, *i.e.*, they consist essentially of combinations of cylinders heated by steam, and steam heated chests or beds. They are usually built on the unit system, the first unit consisting either of (*a*) two steam heated chests in which travel two 9 inch padded rolls, or (*b*) a steam heated cylinder round the periphery of which are mounted four $4\frac{3}{4}$ inch padded rolls. To this first unit—whether cylinder or chests—one or more additional units, each consisting of (*a*) a frame supporting one chest and corresponding roll, or (*b*) a steam heated cylinder, may be added as requiured. In other words the first unit may consist of two chests, or a steam heated cylinder, and there can then be added cylinder to cylinder, chest to cylinder, or chest to chest as desired.

The steam cylinder is almost completely encircled by an endless apron, which is kept in proper position by means of an automatic guide. The apron travels about 14 inches to the foot faster

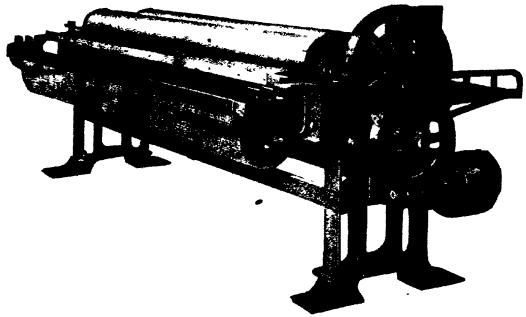


FIG. 71A.—STEAM MANGLE WITH TWO CHESTS. MOTOR DRIVEN.

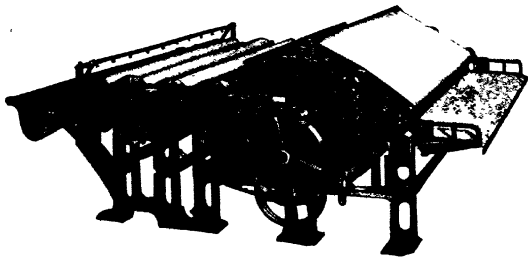


FIG. 71B.—STEAM MANGLE WITH FOUR CHESTS AND ONE CYLINDER. BELT DRIVEN.

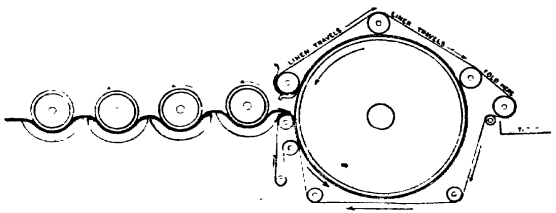


FIG. 71C.—SECTIONAL VIEW OF FIG. 71B, SHOWING TRAVEL OF GOODS.

(J. Armstrong and Co., Ltd.).

than the cylinder so as to impart a better "finish" to the goods, and its position at the receiving table is such that, when a sheet, for instance, is coming from the machine, and the first end reaches the folders, the last end of the sheet is free, and it can be folded at once, whereas in other types of flat work ironers, it is necessary to wait until the articles drop on to the receiving tables. When a combination machine consisting of a cylinder and two or more chests is in use, the goods are ironed on one side by the chests and on the other by the cylinder. A simple eccentric device is provided for raising the padded rolls away from the chests 1½ inches, while each roll can also be raised separately.

The feeding device attached to the cylinder machine is of the ribbon apron type, having a positive hand guard, the chest machines being provided with metal feeds, although the former type of "feed" can be attached to any machine. Fig. 71A represents a two chest machine with motor drive, while a four chest and one cylinder machine is shown in Fig. 71B. Fig. 71C is a diagrammatic view of the latter showing the travel of the goods through the machine.

2. **Collar, Cuff, and Shirt Ironing and Finishing Machines.**—After shirts, collars, and cuffs have been saturated with raw starch, they are placed in a hydro-extractor or passed between the rollers of a wringing machine in order to remove surplus water and starch. They are next straightened out and brushed so as to prepare them for the ironing process.

If boiled starch has been used, however, a different mode of procedure is adopted. Excess of starch is first removed and the goods dried. They are then dampened, allowed to lie for a short time, and finally passed on to the ironing machines.

The ironing process for goods which have been treated with raw starch consists essentially of two main operations known technically as "blocking," and "glossing" or "polishing." The term "blocking" is used to indicate that part of the process which has for its chief objects (*a*), the smoothing out and removal of creases, and (*b*), the partial drying of the goods. At the same time, the inherent stiffening and tenacious properties of the starch are developed in presence of moisture and heat, so that the articles become "set." That stage of the process at which excess of water is converted into steam and the starch gelatinised, is known as "steaming"; hence "blocking" and "steaming" take place concurrently.

It is not customary to discriminate between various stages of the ironing process when the goods have been starched with boiled starch since these are usually ironed by one or more passages through a multiple roller ironer, immediately after removal

from the dampening press. The following classification is adopted for all appliances used in ironing and finishing goods which have been heavily starched, viz. :—

1. Blocking and steaming machines.
2. Glossing machines, including multiple roll collar ironers for boiled starch work.
3. Collar and cuff edge ironing machines.
4. Seam dampeners.
5. Collar and cuff shaping appliances.
6. Neck-band ironing machines.

1.—BLOCKING AND STEAMING MACHINES.

The blocking and steaming of collars, cuffs, shirts, etc., are usually effected with the aid of a machine belonging to one of the following classes, viz. :—

1A. Table ironing machines.
1B. Steam presses.
1C. Machines with rollers and inverted concave irons.

Blocking with hand irons is also a common practice in many laundries. Shirts are blocked and partly finished on machines belonging to the first or second class.

In some cases, both blocking and glossing are carried on with the aid of one and the same machine, but it is more usual to employ, at least, two machines, each of which is specially adapted for one part of the ironing process.

1A. **Table Ironing Machines.**—The chief features of machines of this class are a padded shirt or collar board, and a hollow, highly polished, heated metal roller. When the machine is in use, the board travels backwards and forwards beneath the roller while the latter is revolving in contact with it, so that a considerable amount of friction is exerted at the point of contact owing to the different speeds at which the board and roller travel. The roller is usually heated by means of a mixture of air under slight pressure and gas, and both it and the table are connected to driving-gear, which in the most up to date machines, gives a reciprocating reversing motion.

A well known type of table ironing machine is shown in Fig. 72. Attached to a suitable framework is a highly polished hollow metal roller, beneath which is a table of cast iron and wood. The table fits into grooves at the sides of the machine and is covered with felt over which calico is stretched tight by means of a ratchet wheel and key; it moves horizontally in the grooves between the polished roller and a driving cylinder, and can be adjusted ver-

tically by means of a hand lever placed at the side of the machine. This lever is connected to the driving cylinder placed beneath the table, and causes it to rise or fall at will, a similar movement being thus imparted to the table. Hence, the pressure between the latter and fixed polished roller can be easily regulated. The driving gear consists of fast and loose pulleys with two narrow belts, one of which is crossed and the other open.

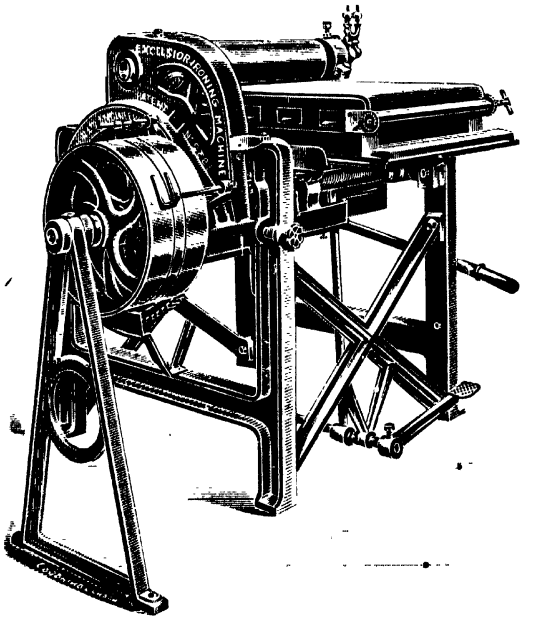


FIG. 72.—"TABLE" IRONING MACHINE.
(*Glover and Hobson, Ltd.*).

The polished roller is heated by means of a mixture of gas and air, which passes into the interior of the roller through a perforated tube or burner extending the whole length. This burner is provided with the necessary cocks for the proper adjustment of gas and air.

When the machine is not in actual use, the heated roller revolves outwards, *i.e.*, away from the operator, and the driving cylinder inwards, but when the machine is being used, depression on the foot treadle shifts the belts on the pulleys; this causes the rollers to reverse their rotation, thus taking the table—on the top of which the goods to be ironed are placed—between them.

The outward motion again occurs on releasing the treadle and the table travels to the front of the machine. The polished roller travels a little faster than the driving cylinder, so that a certain amount of "slip" is induced, thus facilitating the production of a lustrous surface on the goods being ironed.

Shirt bosoms and attached cuffs can be ironed on this type of machine by substituting a special shirt board for the usual padded table.

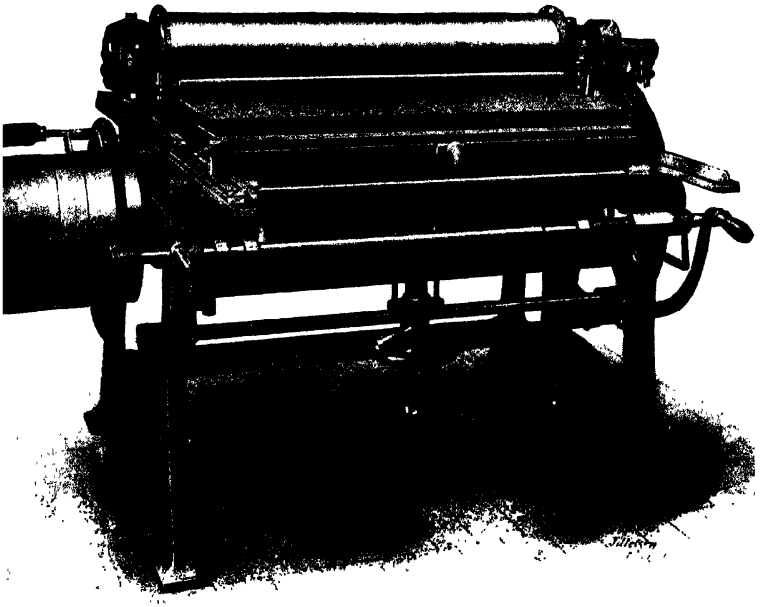


FIG. 73.—SELF-REVERSING BLOCKING MACHINE.
(Cherry Tree Machine Co., Ltd.).

Another machine of the same type as the above but differing in several particulars is shown in Fig. 73. Its distinguishing features are a very wide collar board; the provision of handles instead of treadles for starting and stopping purposes; an automatic self-reversing motion which enables the table to be reversed at any point in the travel; and a hand wheel and screw arrangement for adjusting the pressure on the ironing surface without moving the gear wheels, thus ensuring that the wheels are always

in the same depth of gear. The table can be instantly lowered in the event of a belt breaking while it is under the heated roller. It is covered with a sheet of indiarubber over which is placed a piece of thin felt and finally a sheet of calico. The pressure is obtained by means of a spiral spring, which readily yields to the various thicknesses of linen being ironed.

This machine is specially adapted for blocking a large number of collars or cuffs at one operation, but in order to utilise its obvious advantages to the fullest extent, it is necessary to employ it in conjunction with one of the various types of rapid glossing machines described in the following section.

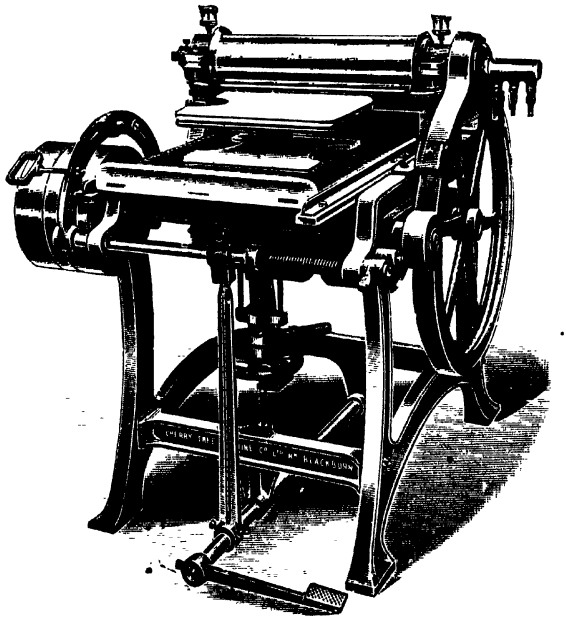


FIG. 74.—"TABLE" IRONING MACHINE WITH SHIRT BOARD.
(Cherry Tree Machine Co., Ltd.).

When the bosoms of shirts are ironed on table machines, it is customary to use a board of the approximate size and shape of a shirt front. This is fixed to the table of the machine in such a way, that sufficient space is left beneath the roller on either side to enable the shirt bodies to be readily manipulated.

Two interchangeable boards are supplied with most modern machines, one of which is designed for use with collars, cuffs,

and fronts, and the other for shirts. Fig 74 illustrates a machine fitted with a patent shirt board of a reversible type. It is claimed that, by the use of this board (Sekian's), shirt bosoms of any size can be ironed without leaving the usual objectionable mark down the centre. In use, one half of the bosom, and one cuff are first blocked; the board is then reversed without removing the shirt. Finally, the remaining half-bosom, and cuff, are ironed in the same way. The bosoms are ironed across, instead of up and down as is the case with the usual form of board. The machine is built on similar lines to those mentioned in connection with Fig. 73, with the exception that a treadle is used for stopping and starting purposes.

For ironing Oxford and negligé shirts—plain or pleated—a special board provided with stretching apparatus is sometimes employed. It is furnished with an automatic neckband and yoke clamp, as well as a ratchet stretcher. The bed of the board is grooved down the centre and inlaid with rubber, which lies directly beneath the row of buttons on the shirt, thus forming a yielding bed and preventing them from breaking.

The rollers of table ironing machines are frequently made in different sizes to suit the goods for the ironing of which they are to be used. Thus, the width of the roller of a machine designed for shirts only, is about equal to the width of the shaped shirt-board, while the diameter is greater than in the ordinary type of machine. This mode of construction results in a greater area of heated ironing surface, and gas is not wasted by heating parts of the roller which are not required. The usual widths are 18 and 24 inches, as already mentioned. In order to ensure complete combustion of the gas used for heating purposes, and to obtain the requisite temperature, it is necessary to mix it with air under pressure before it enters the roller. Separate pipes are provided for the gas and air, as well as suitable regulating valves, which latter are fixed near the machine.

The air is delivered under pressure by means of a fan or blower, and this communicates with a main distributing pipe from which the various machines are supplied through smaller branch pipes.

A modification of the above system of heating is based upon the principle that if compressed gas be passed into a suitable burner provided with an arrangement for the admission of air, the latter is drawn into the burner in sufficient quantity to ensure complete combustion. Thus, it is evident that only one main pipe containing the compressed gas is necessary. This system is more fully described in Part II.

In many laundries both the "blocking" and glossing of shirts, collars, and cuffs are done with the aid of ordinary table ironing machines. It is evident, however, from a consideration of the constructional details and mode of working of these machines, that only a comparatively small portion of the heated roller comes into actual contact with the goods being ironed. Consequently, several passages between the roller and board are necessary before they can be properly "blocked."

It is considered by some authorities that goods treated in this way are subjected to undue wear and tear, and several machine makers have introduced machines specially designed to diminish the length of time occupied in the "blocking" operation, thus facilitating the whole process of ironing.

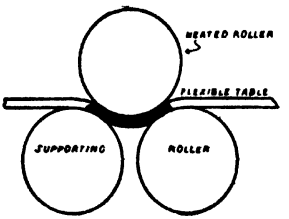


FIG. 75A.—DIAGRAM SHOWING AREA OF CONTACT OF BED WITH HEATED ROLLER. ("FLEXIBLE TABLE" IRONER) (*I. Braithwaite and Son, Ltd.*).

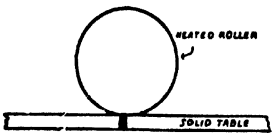


FIG. 75B.—DIAGRAM SHOWING POINT OF CONTACT OF BED WITH HEATED ROLLER. (ORDINARY TABLE IRONER).

One of these machines is a modified form of the ordinary table ironer. Its chief distinguishing feature is the provision of a flexible table, which is arranged in such a way that, when in use, it comes into contact with a comparatively large area of the heated roller, while in the ordinary type of machine there is only a line of contact between the roller and board.

The table is of canvas, covered with felt, so that moisture from the goods is more or less readily removed. Two supporting rollers (Fig. 75A), which also act as guides, are provided, and above these is the usual gas heated roller. By means of suitable springs, the two guide rollers are forced against the heated roller, and varying degrees of pressure can be easily obtained, while the nature of the table and its mode of arrangement supplies the necessary degree of elasticity. For purposes of comparison a section of the bed and heated roller of the ordinary type of table ironer is shown in Fig. 75B.

1B. **Steam Presses.**—Instead of using table machines in the preliminary ironing operations, steam presses may be employed with advantage. These differ entirely from all the machines previously described, both as regards constructional details and mode of working. They are eminently adapted for blocking and partially drying heavily starched goods, prior to the glossing operation, and are of the highest service in turning out work rapidly, while it is generally admitted that their use results in goods being subjected to much less friction than that which is set up when table machines are employed.

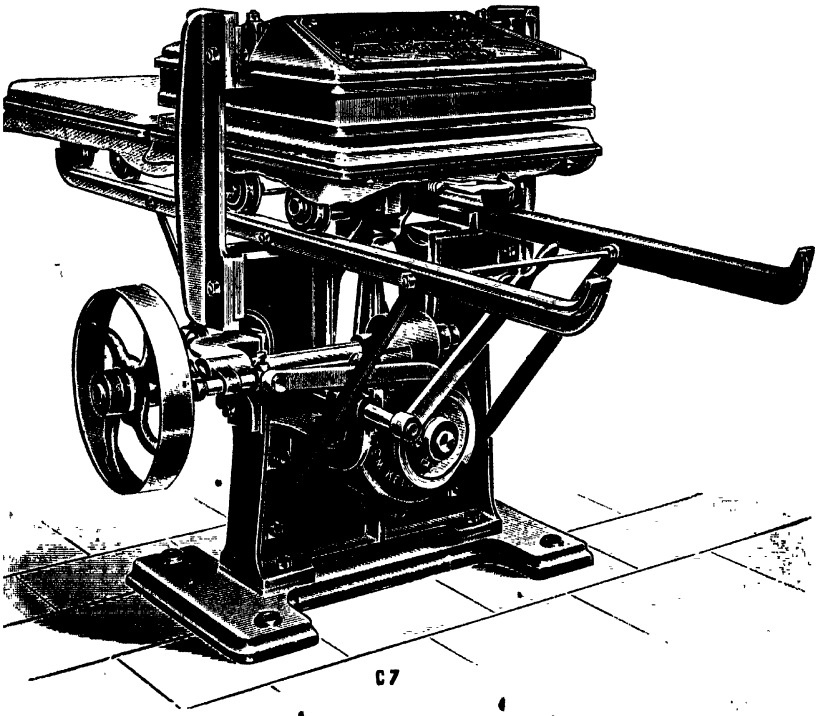


FIG. 76.—POWER PRESSING MACHINE.
(W. Summerscales and Sons, Ltd.).

Fig. 76 represents a typical blocking machine built on the press principle. A hollow head or iron polished on one side is carried by two side arms attached to a suitable framework, and is arranged in such a way that the flat polished side is directed

downwards. The iron is heated by means of steam and is capable of withstanding a working pressure of 100 lb. per square inch.

Immediately beneath the heated head are fixed two horizontal iron guides or supports upon which run two felt covered iron tables. The latter can be raised against the polished iron or lowered, as the case may be, by means of an eccentric and link motion driven by a worm and worm wheel from a pulley attachment. In operation, one table charged with collars, is being pressed upward into contact with the heated iron, while the other is being filled with collars ready for pressing, and so on alternately.

The rising motion automatically stops when the goods are in contact with the heated iron, and the length of time they are allowed to remain in this position is governed by the amount of moisture present, the temperature of the iron, the degree of dryness required, and the condition of the felt covering. About five to ten seconds is considered to be ample with a steam pressure of from 50-80 lb. per square inch; the motion is then reversed so that the table takes a downward direction, and is also automatically stopped at the point where the tables are changed. Each set of collars is first pressed on one side, then turned over and pressed on the reverse side. They are then finished on table machines, or on multiple roller collar ironers.

In the construction of all machines of this type a great deal of attention has been paid to the consideration of means for keeping the felt in a fairly dry condition, so as to ensure uniform and rapid work.

The method adopted in the machine under consideration, is to allow the vaporised moisture to pass through the padding and along a large number of narrow grooves cut in the table top, from whence it escapes at the edges. The porous nature of the padding and the large number of grooves allow the moisture to escape so readily, that it is quite possible to work the machine continuously without the necessity of changing the padding. The latter consists of a cork pad on the top of which is placed a sheet of thin felt or cloth and finally a layer of calico.

Fig. 77 shows an ingenious type of ironer which combines a pressing motion with a slow gliding movement during the time the goods are in contact with the polished under surface of a steam heated chest. The latter is heated with steam at a pressure of about 50 lb. per square inch. In operation two collar tables are employed, one of which is being loaded while the other is in contact with the polished bed. As in other press machines, two contacts are necessary, the first one on the surfaces of the goods, occupying from about 5-8 seconds, *i.e.*, the time occupied from the

starting to the automatic stopping of the machine. The board is then withdrawn, the collars, etc., turned over, and any creases that appear smoothed out according to the usual custom. Finally, the articles are pressed again, a sliding motion taking place at the same time, thus effectually preventing the goods from sticking to the heated iron; this operation lasts from about 8-15 seconds according to the degree of dryness required. The collar boards are interchangeable with shirt boards, and upon each of the former, two rows of collars are pressed at the same time. The latest practice with this machine is to iron the collars "bone-dry," and then to damper them on the surfaces by means of a special machine (Fig. 112). Finally they are finished by passing them through a rotary "glosser" of the type shown in Fig. 86.

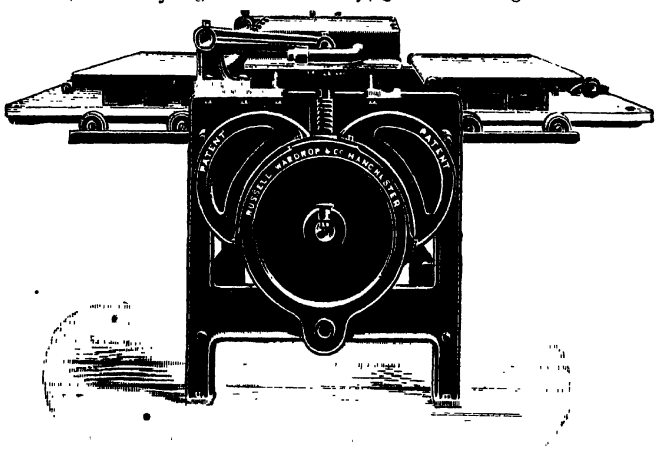


FIG. 77.—"SEMI-PRESS" IRONER WITH COLLAR BOARDS. STEAM INLET SIDE.
(*Russell, Wardrop and Co.*).

Steam Cuff Presses.—Separate steam presses specially designed for ironing the wristbands and cuffs attached to shirts are now in frequent use. They are of especial value in the ironing of cuffs attached to sleeves with short gussets, although they may also be used for detached articles. A pair of typical cuff presses is illustrated and described in the account of the American press plant for shirts given below.

Steam Shirt Presses.—In the majority of laundries, the bosoms, neckbands and cuffs of shirts are ironed either on table machines or by hand. During the last few years, however, several ingenious

machines designed on the press principle have been introduced for shirt finishing and it appears to be highly probable that the future development of ironing machines for heavily starched goods will be on the same principle, for it is becoming more and more recognised that ironing by pressure more nearly approaches hand work than any other method, while excessive wear and tear are avoided.

We have previously given a description of the Russel-Wardrop semi-press machine, which is suitable either for collars or shirts. As already stated the boards are interchangeable, and upon each shirt board, two half-bosoms (or a whole one) and two attached cuffs are pressed at the same time. The steam exhaust and driving side of this machine, with the shirt boards in position is shown in Fig. 78. After pressing, the bosoms are finished by a few passages beneath the roller of a table ironing machine. Summerscales' steam press described on page 192 is also made with non-interchangeable boards for shirts only, and with one

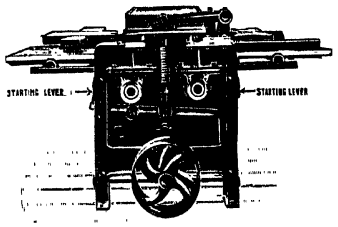


FIG. 78.—"SEMI-PRESS" IRONER WITH SHIRT BOARDS.
(*Russell, Wardrop and Co.*).

board for collars and the other for shirts. The latter form is suitable for a medium sized laundry. A "shirt-board" of this machine really consists of three comparatively high padded boards, viz. :—A central one for holding a bosom (this being provided with a clamp for keeping the neckband in position), and a small board on each side for the attached cuffs. In most other respects the machine is similar to the collar press and is operated in the same manner

American Press Plant.—In many of the large laundries complete shirt press plants comprising individual machines for ironing the bosoms, cuffs, yokes, and neckbands are in use. A plant of this nature is only suitable, of course, for works in which large quantities of shirts are dealt with, and appears to be specially adapted for the production of a "domestic finish," *i.e.*, a finish possessing little lustre. If a "glossy finish" is required, the articles need to be polished subsequently either by hand or on a

suitable machine. An American plant (suitable for a large laundry), which is stated to give excellent results, consists of the following machines, viz. :—

1. Two cuff presses.
2. Combined neckband and yoke press.
3. Bosom press.

Cuff Presses.—The front view of a pair of typical cuff presses is shown in Fig. 79, while Fig. 80 represents an enlarged view of the "head." They are chiefly used for

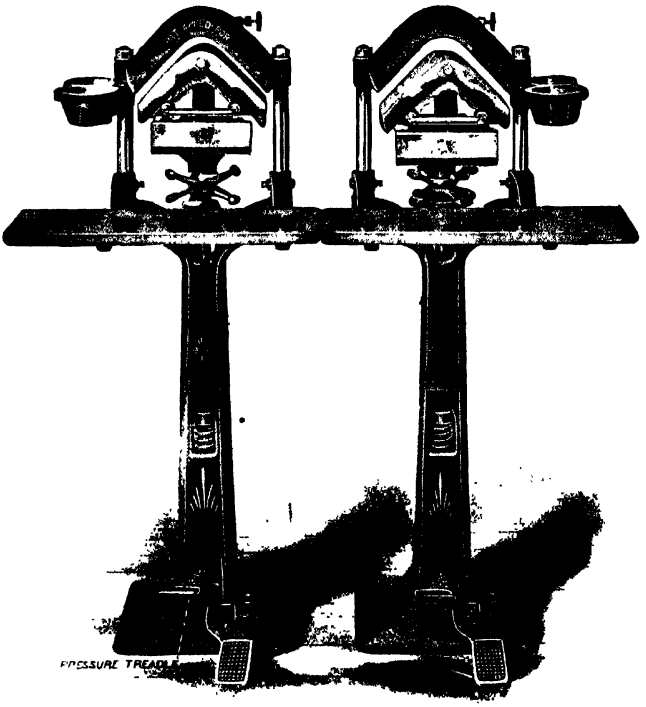
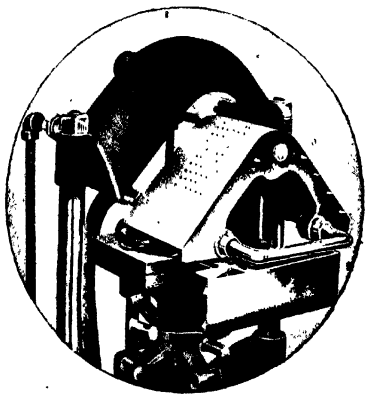


FIG. 79.—CUFF PRESSES. FRONT VIEW.
(I. Braithwaite and Son, Ltd.).

ironing wristbands and attached cuffs, although they may also be employed for loose cuffs. Each press consists of an "A" or saddle-shaped steam chest, beneath which is a "head" of the same shape. This particular shape is adopted so that

wristbands with short gussets can be as easily ironed as those with long gussets, while at the same time, the cuff is moulded into the requisite shape. The steam chest is provided with a steam inlet and two outlets for the condensed water. The "head" is hollow, and perforated on the upper surface with small holes, through which air is forced under pressure during the whole of the time that the machine is being utilised. On top of the "head" are placed several thicknesses of felt covered with a layer of muslin, this being termed the "padding." When the machine is in use the compressed air passes through the padding, thus keeping it dry and enabling a greater output to be obtained in a given time, while fresh coverings are required at less frequent intervals. By means of a handle and sliding device, the "head" can be withdrawn for the purpose of placing a cuff in position or removing it. Fig. 80 shows the "head" after withdrawal, but without the padding. Two treadles are provided, one of which is used to apply



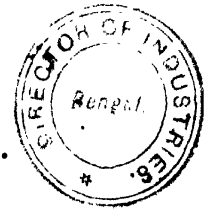


FIG. 80.—"HEAD" OF CUFF PRESS.
(J. Braithwaite and Son, Ltd.).

the necessary degree of pressure to the cuff, while pressure on the other causes the "head" to fall away from the steam chest and cushion against a spiral spring with little or no noise. Rubber hose is used for establishing communication with the air pump. The latter is built with a hollow base which constitutes a reservoir for storing up air for use in the event of the pressure on several machines being released at the same time. Cuff presses are usually employed in pairs, so that a cuff can be pressed on one machine while the operator is removing a cuff from the second press and placing another in position. Instead of two single

presses, a double press may be used. In this form the " heads " are generally steam heated for keeping the padding dry.

Neckband and Yoke Press.—Fig. 81 illustrates a combination press. A strong iron standard is provided with an arm on each side. Attached to one arm is a steam heated chest of a

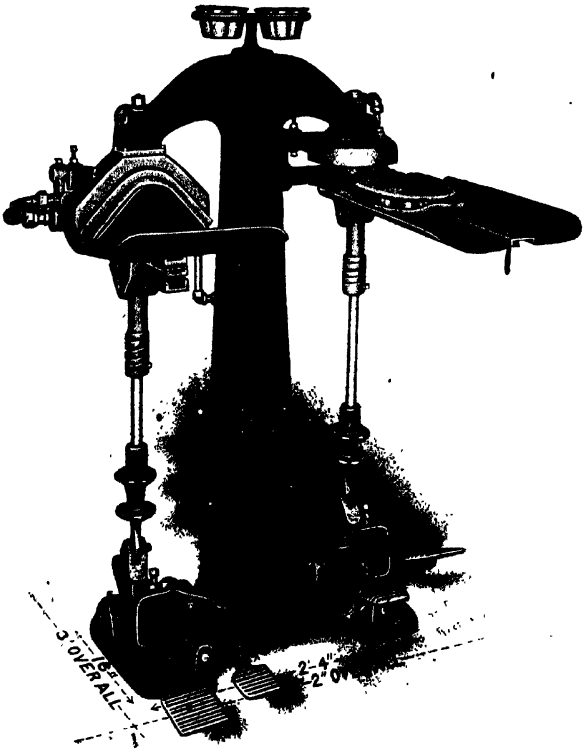


FIG. 81.—COMBINED NECK-BAND AND YOKE PRESS.
(*By Braithwaite and Son, Ltd.*).

similar shape to that on the cuff press, but much longer and not so wide. The padded " head " is also of the same shape and is steam heated in order to keep the padding dry. In other respects the constructional details and mode of working are somewhat similar to those adopted in the case of the cuff presses. On the

right hand side of the machine is the yoke press. This is provided with a flat square "head" which can be brought into contact with a flat steam chest by means of a pressure treadle. The padding is kept dry in the same way as in the neckband press. Attached to the head is a clamp for holding the neckband, while another clamp serves for the purpose of stretching the yoke so as to remove all creases before ironing. With the aid of this machine, the insides of the yokes of shirts can be easily ironed and set, thus preventing the backs of the shirts from bulging out.

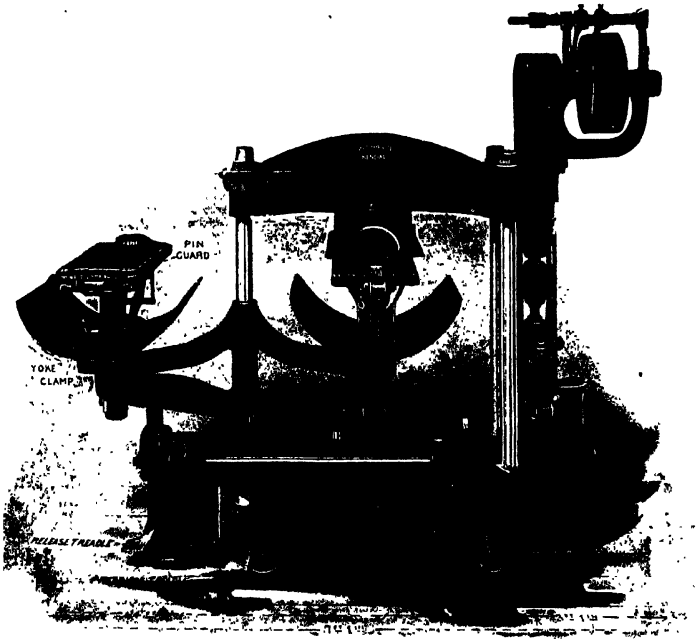


FIG. 82.—"BOSOM" PRESS.
(I. Braithwaite and Son, Ltd.).

"Bosom" Press.—The constructional details and mode of working of a form of press largely used for ironing the bosoms of shirts will be readily understood by reference to Fig. 82, and the description given below.

In this apparatus, two pumps are provided, one for oil and the other for air. When the machine is in use, the latter works continuously, while the former is brought into action when required

by means of a pressure treadle. Both pumps are driven by the same piston rod. The air pump is shown in the illustration, but the oil pump is hidden from view owing to its being immersed in the hollow base of the press which acts as an oil reservoir. In the centre of the base is a hollow cylinder of about 4½ in. diameter, and in this, a plunger travels up and down. Two pivot arms are attached to the left hand upright of the frame of the machine on ball bearings, and at the end of each arm is fixed a bosom bed. A release treadle enables each arm to be swung alternately into position beneath the steam chest, and an interlocking device prevents the bed from being raised until it is in proper position. The lower end of each arm is hollow and conical shaped at the mouth, so as readily to allow the upper end of the plunger to adjust itself easily in position when it begins to rise. By depressing the pressure treadle, oil is forced into the cylinder of the pump, and the bed rises until it comes into contact with the steam heated chest when pressure is exerted until it reaches 550 lb. per square inch, at which point the oil pressure is automatically cut off. In this way a uniform pressure is obtained. The bosom beds or shirt boards are perforated and covered in the usual way with woollen pads and cotton cloth. Air is forced through the padding by establishing communication between the hollow bed and the air pump with the aid of a rubber pipe. By adopting this plan, the felt is kept in good condition, since the air in passing through the perforations, readily vaporises the water absorbed from the goods. A steam inlet pipe and a pipe for the escape of condensed steam are attached to the chest.

The beds are provided with contrivances for stretching the bosoms of the shirts in position and for clamping the yokes. An adjustable neckband ring is also employed; it is suitable for any size of neckband.

While one shirt is being pressed, another is being fixed in position on the second bed. It is usually found that at least two pressings of each shirt bosom are necessary. After the first pressing, the overlapping edge of one side of the shirt bosom leaves a slight impression on the part beneath, so that in order to remove it, very thin plates of metal—which are kept hot in a suitable box when not in use—of the shape of one half of the bosom of a shirt are employed. When the first or second pressing, as the case may be, is finished, the overlapping edge is raised, a "shape" placed in position on the shirt front with the overlapping edge on top. Pressure is then applied, with the result that the overlapping mark is obliterated. The use of hot plates also serves to prevent the formation of water stains. With this

machine, a glossy finish is not obtained, but the surfaces of the shirt bosoms are rendered extremely smooth and uniform, and

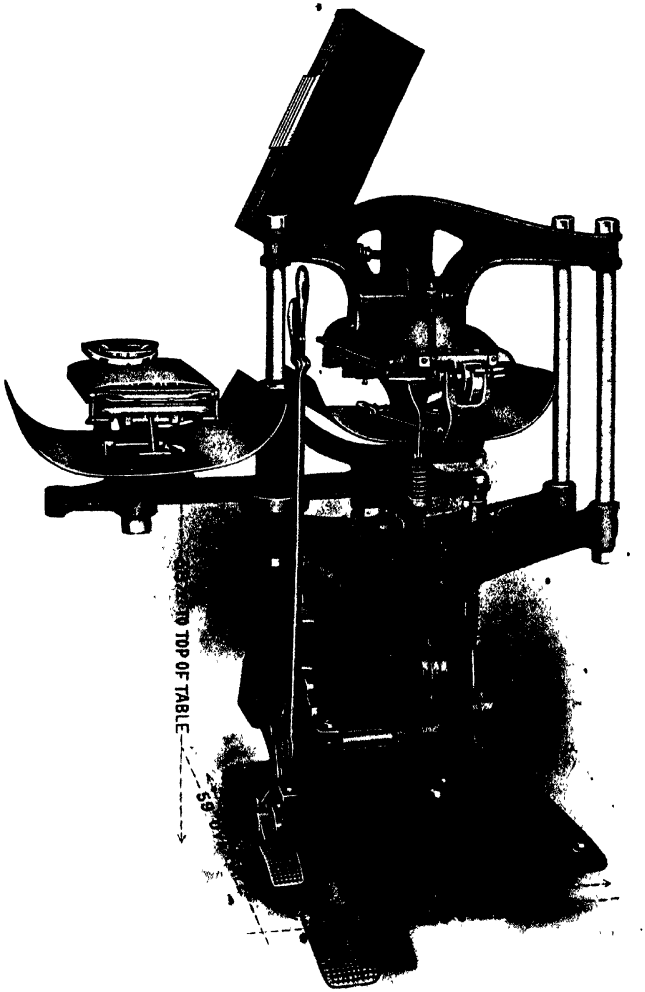


FIG. 83.—"BOSOM" PRESS. HAND POWER.
(*J. Braithwaite and Son, Ltd.*).

exhibit an appearance, which, so far as a domestic finish is concerned, leaves little to be desired.

The *modus operandi* adopted in a large continental laundry with the foregoing shirt plant, for goods which have been starched with raw starch, is as follows :—

1. Lightly press cuffs on right side and then on wrong side. Finish on right side.
2. Press the neckband in the same way as cuffs.
3. Press the yoke after carefully placing in proper position.
4. Iron the front on bosom press, first on right side to set the starch, then again on same side after making sure there are no creases, etc. If necessary the metal plate is then used for the overlap.

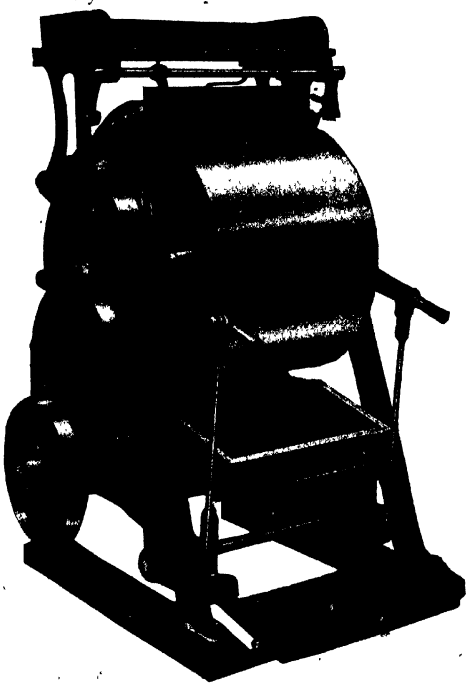


FIG. 84.—ROLLER AND INVERTED IRON BLOCKING MACHINE.
(*J. and J. Lane, Ltd.*).

For small laundries, institutions, hotels, etc., where power is not readily available, a hand power bosom press of the form

shown in Fig. 83, is highly serviceable. This works on much the same principle as the power press described above, and can be built either with one or two beds. In operation, the shirt bosom is placed on the bed of the machine and clamped in position by means of a special clamp and expander. Pressure is then applied by pushing up the large lever, which raises the bed in close proximity to the chest; then, by stepping on the main treadle, the bed is brought into contact with the chest under heavy pressure, and locks in that position. When the shirt is ready to be removed, the operator steps on the small treadle, which action unlocks the larger treadle and releases the pressure; on pulling down the large lever, the bed drops to its normal position, and by again depressing the release treadle, the beds are unlocked and may be swung round as required.

1C. **Machines with Rollers and Inverted Concave Irons.**—A blocking machine belonging to this class is shown in Fig. 84. It consists of an inverted hollow iron, shaped to fit a large hollow roller covered with felt. The iron can be heated either by steam or gas and is polished on the side which is in contact with the roller. In use, the roller is caused to revolve by means of suitable gearing, and can be immediately stopped by the application of pressure to the footboard, the same action bringing the concave iron into contact with the roller. At this stage, a collar is placed on the roller bed, the operator steps off the treadle and the roller revolves. When the collar has passed beneath the heated iron, pressure is again applied, another collar placed on the bed, and so on, one collar being steamed while another is being arranged on the bed. To prevent sticking, the motion is so arranged that the roller starts before the iron is raised, thus skidding the collar off.

2.—GLOSSING MACHINES; AND IRONERS FOR BOILED STARCH WORK.

As already mentioned, glossing, as well as blocking, is frequently done on table ironing machines; in many works, however, blocking is now done with the aid of a steam press, and the subsequent glossing on a table machine. Again, blocking may be done with a press, a concave iron machine, or an ordinary or large capacity table machine, and the glossing operation on a roller machine.

Roller glossing or finishing machines are used to a very large extent in America in connection with the boiled starch process, and modified forms of these appear to be meeting with increased

favour in this country. Strictly speaking, the glossing operation consists of a preliminary drying operation followed by the actual glossing. Thus, it naturally follows, that a greater or less number of contacts with a heated polished surface is necessary before the desired finish is obtained. With regard to the ironing of goods treated with boiled starch, it is to be observed that these are purposely rendered only very slightly damp, so that they can be readily "set" and glossed by one or more passages through a suitable roller machine, without having first to undergo a more or less elaborate blocking operation. The number of passages requisite is governed by the amount of moisture in the goods, the temperature, speed, and number of rollers, and the degree of gloss required, as well as other minor conditions.

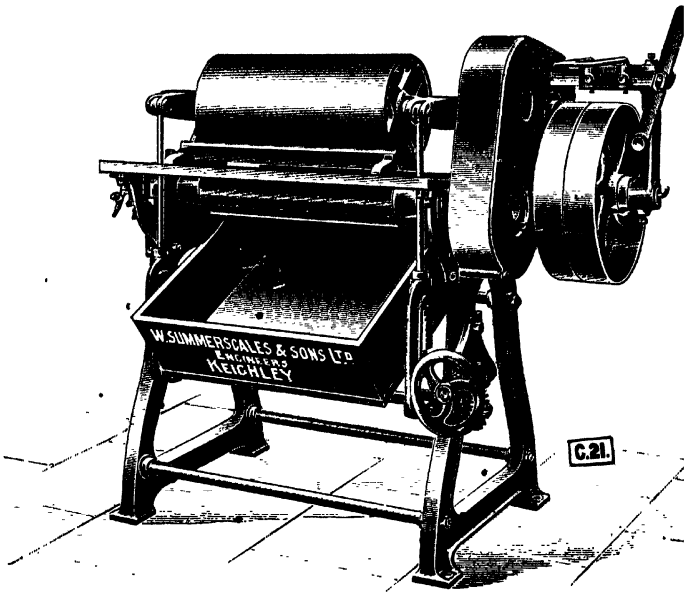


FIG. 85.—"EMPRESS" COLLAR AND CUFF IRONER.
(*W. Summerscales and Sons, Ltd.*).

Roller Glossing Machines.—The noticeable feature of machines of this class, is the provision of small, highly polished rollers, heated by gas or steam. The heated rollers revolve in contact with one or two large felt-covered rollers, the rate of revolution of each type of roller being so arranged that consider-

able friction is set up at the points of contact. The amount of friction produced in this way, may be varied at will in many of the large machines by the use of interchangeable gear, so that either a high or a medium gloss may be imparted to the goods by a single passage through the machine, provided, of course, they are in a suitable condition. In some machines the small heated rollers are replaced by padded rollers revolving in contact with a large heated roller, but the underlying principles upon which the efficiency of these machines depend are the same in all cases. In the simplest form of machine (Fig. 85) there are only two rollers, one of which—the lower one—is heated and the other padded. The latter is 12 in. in diameter and is carried in a swinging frame, so as to ensure a perfectly true parallel pressure on the lower roller.

The pressure is obtained by means of suitable gear and springs. In order to obtain a satisfactory finish on linen or cotton with the aid of a two-roller glossing machine, it is necessary to pass the goods between the rollers several times. These operations are facilitated by the provision of a wooden tray which is fixed beneath the machine at such an angle that the ironed goods are returned to the front of the machine.

In some double roller machines the heated roller is placed above the padded roller.

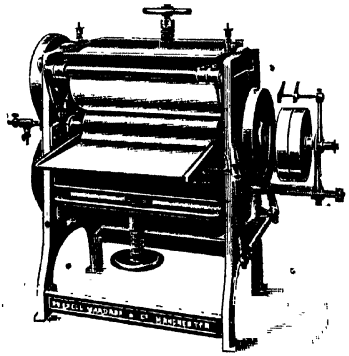


FIG. 86.—THREE-ROLL GLOSSING MACHINE.
(Russell, Wardrop and Co.).

Three-Roll Glossing Machine.—This type of machine differs from the foregoing in that it is provided with an additional padded roller and a guide which cause the goods to be returned automatically to the feed side of the machine, while at the same time they receive a second nip between the heated and padded rolls.

A typical three-roll glossing machine is shown in Fig. 86. It is made in two sizes, with rollers 14 inches and 24 inches long respectively. The former deals with articles in single pairs, the latter in double pairs. The middle roller is of metal heated by gas and highly polished. Above and below this is a padded roll. In operation, the goods are passed between the two lower rolls and are returned automatically to the operator through the top rolls. An important improvement for ensuring an even set pressure on the rolls

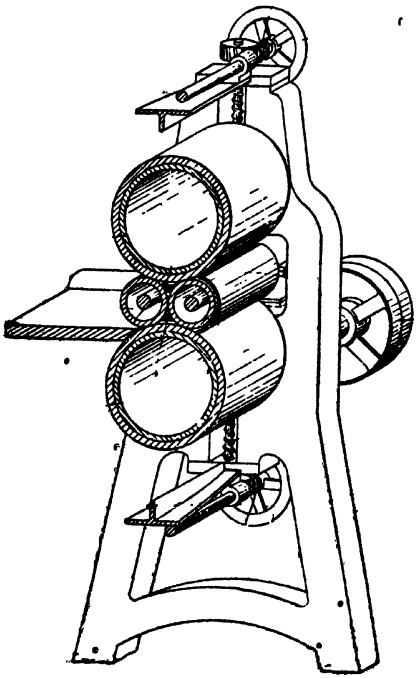


FIG. 87.—"FOUR-CONTACT" GLOSSING MACHINE.
(Hill and Herbert, Ltd.).

irrespective of the varying thicknesses of the padding, has been recently patented. On turning the pressure screw, a point is ultimately reached at which a locking pawl is thrown in automatically. The point at which this occurs, is, of course, the previously determined correct pressure, and the action is independent of the "thinning down" of the padding. Another patented device has been introduced for the purpose of relieving the padding of the

"drag" which occurs during working. This result is achieved by means of a pressure release arrangement, whereby the pressure on the padded rolls is released momentarily at each revolution, thus preventing the padding from working forward.

The machines described above are characterised by the possession of only one heated roller, and collars and cuffs require two or more passages before a satisfactory finish is obtained, hence such machines are unsuitable for dealing expeditiously with large quantities of goods.

For very rapid work, ironers with two or more heated rollers have been introduced. These are built on the same principles as the small machines but they are so arranged that the goods are subjected to pressure at several points during a single passage, while at the same time they are in contact with (*a*) a heated cylinder throughout their passage or (*b*) heated rollers at the points of contact only. A distinguishing feature of one type of rapid ironer of recent introduction is the provision of a heated concave iron as well as a heated roller.

Hill and Herbert's "*Four-Contact*" *Glossing Machine*, Fig. 87, has been designed with the object of causing collars and cuffs to come into contact with the ironing rollers four times, during a single passage through the machine. The apparatus consists essentially of two small heated ironing rollers which revolve in contact with two large padded rollers. The latter are pressed into contact with the former by means of springs which can be adjusted by worm gearing and hand wheels. Suitable guides are placed between the heated rollers, while a guide plate is attached to one side of the latter as shown in the diagram.

Fig. 88 illustrates a five roll ironer. Supported in suitable bearings is a felt covered hollow cylinder 22in. in diameter, round the periphery of which are mounted five highly polished steel rolls, each 27in. long and $5\frac{1}{2}$ in. in diameter. These rolls are usually heated by gas, and are geared in such a way, that there is a considerable amount of slip between them and the central drum, owing to difference in speed. They are provided with guides to carry the goods from roll to roll, while sufficient space is left between each to facilitate the escape of steam. An arrangement of endless tapes serves for the purpose of returning the ironed articles to the front of the machine. Pressure is obtained by means of spiral springs, and is applied automatically by the operator standing on a footboard, the machine being started at the same time.

It is claimed that this machine is capable of both blocking and finishing collars and cuffs at a very rapid rate, three times

through being sufficient for such articles when starched with raw starch. It is also said to be well adapted for ironing napery, and collars, cuffs, etc., direct from the dampening press (boiled starch process).

A well-known type of multiple roller collar and cuff ironer, specially designed for boiled starch work (collars, cuffs, etc.) is shown in Fig. 89. The chief points of construction and the mode of working will be readily understood by reference to the illustration. It is built in two widths, viz.: 24 in. and 40 in.

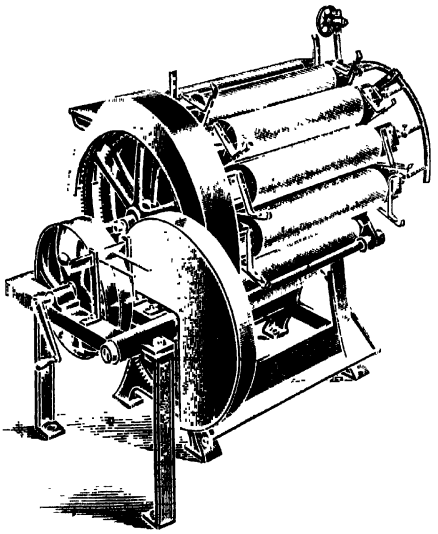


FIG. 88.—FIVE-ROLL IRONER. FRONT VIEW.
(*J. Appleyard*).

The former is supplied either with two, three, or five heated rolls, and the latter with two or three. The two and three roll machines are suitable for imparting a domestic or medium gloss, and the five-roll machine for a high gloss finish. Interchangeable gear is provided, this being used according to the kind of finish required. Two rolls of large dimensions, well padded with absorbent material are fitted to each type of machine. When the machine is in use, the goods are introduced at one end and emerge at the other after having passed between two or more heated rolls and the padded rolls. It is stated that a single passage serves to finish collars and cuffs received from the dampening press.

Instead of using gas for heating the rollers of multiple ironers, steam may be employed, but, as a general rule it is not nearly so efficient as gas. Steam heated machines offer certain advantages, such as freedom from soot and dirt and easy control of the source of heat, so that the rollers are readily kept at a uniform temperature and the ironer can be made hot enough for use in a few minutes. A sectional end view of a steam-heated machine, showing the chief features and mode of working is represented in Fig. 90. Two heated rollers are provided, one of which is 6 in. and the other 16 in. in diameter. The latter irons the face of the collar while the

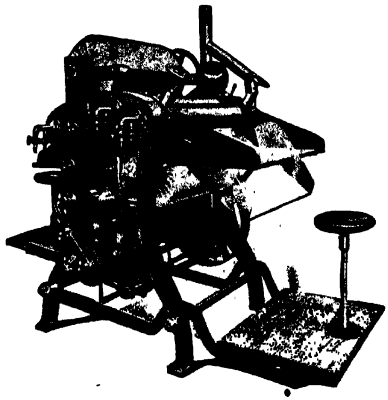


FIG. 89.—MULTIPLE-ROLL COLLAR AND CUFF IRONER.
(J. Armstrong and Co., Ltd.).

former irons the reverse side. In contact with the periphery of the large roller are five small padded rollers, a single padded roller being mounted in contact with the small heated roller. Thus the collars are subjected to pressure between the hot and padded rollers at six points during their passage through the machine. The pressure is applied by means of a lever which brings the padded rollers into contact with the large heated cylinder in unison, the bearings of the latter being stationary. This pressure lever adjusts the rollers to four different stops or positions. At the first position the gears are clear, leaving the rollers free for removing the coverings. The second position throws them in mesh, but keeps the rollers clear of the steam cylinder. In the third position, the pressure is applied, and when the rollers are newly covered, sufficient pressure for ironing is obtained. The fourth position causes additional pressure to be applied, and is used when

the coverings of the rollers have become packed down or worn.

A separate lever is provided for applying pressure to the smaller heated roller.

Both steam inlet and outlet connections for the heated cylinders are placed together at the same end, this being possible by using a syphon for removing the condensed water; thus only one stuffing box is necessary for each cylinder.

The speed of the larger roll may be varied by means of a clutch, so that a high or medium finish can be obtained. Between the second and third padded roll there is a square bar which is driven from one end. This bar revolves and its edges successively tap the collars at intervals of about one inch, as they pass

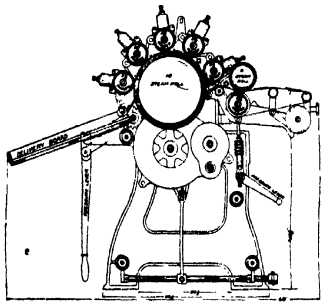


FIG. 90.—STEAM-HEATED MULTIPLE-ROLL IRONER. SECTIONAL END VIEW.

(I. Braithwaite and Son, Ltd.).

upwards from the second to the third padded roll. Thus the collars are kept from curling and are properly fed under the third roll.

In use, the collars are fed into the machine and pass between the small heated roll and its auxiliary padded roll; they then pass between the large steam heated cylinder and padded rolls. The machine is furnished with either a straight feed board or a feed apron over the entire width of the ironing surface.

Instead of a large heated cylinder round which are mounted padded rolls, the mode of construction is frequently reversed. Thus, in one typical machine there are five small steam heated rolls and two padded rolls. Each of the former is $5\frac{9}{16}$ inches, and the main padded roll $17\frac{1}{2}$ inches in diameter. The small padded roll revolves in contact with a steam heated roll, which irons the wrong side of the collar, and the face side is then ironed during the passage of the collar

between the remaining steam heated rolls and the large cylinder. At one end of each heated roll is fitted a syphon stuffing box, which has both live steam and drain connections, while the journals of the rolls are carried in fixed bearing boxes. Pressure adjustment of the main padded roll is accomplished by weights, and the journals of both padded rolls are carried in movable bearing boxes on cushion springs, which give an even pressure and yet allow for variation in thickness in collars passing between the rolls. The whole of the rolls are driven by means of a clutch pulley and gear, and a compound gear changing wheel is provided for high or medium gloss finish.

3.—COLLAR AND CUFF EDGE IRONING MACHINES.

In order to produce smooth edges on collars and cuffs, which have become more or less ragged by wear and tear, or are rough owing to the presence of exuding starch, it is customary to pass the goods through an edge ironer, of which there are several types. One of the simplest takes the form of a hollow steam-heated iron, in the top of which are several grooves of different widths. An arm attached to the main framework, serves as a support for a small vessel containing water, in which revolves a felt covered roller. The edges of the collars or cuffs to be ironed are first moistened by drawing them by hand over the wet roller; they are then immediately drawn through the grooves of the heated iron. As a rule, one or two passages are sufficient to smooth the roughest and sharpest edge.

Fig. 91 illustrates an edge ironer of modern design. It consists essentially of a cone-shaped metallic disc—usually electro-plated—provided with grooves of varying widths, so as to allow for different thicknesses of collars and cuffs. The disc is caused to revolve by means of a belt pulley through bevel gear, and is heated by an atmospheric burner. An arm attached to the machine, supports a suitable water tank containing a felt roll, upon which the edges of the goods are moistened immediately before placing them in the grooves.

Edge ironing is sometimes done with the aid of a combination collar finishing machine. In one type, designed for non-fold collars, the edges are automatically moistened and ironed, and the collar shaped at one operation.

The "*Shaw*" *Ironer and Shaper* is specially adapted for ironing and "setting" the folded seams of turn down collars, and is one of the best-known machines of its class. It is made to

attach to a table, or portable stand, and takes the form of a curved metal plate $\frac{1}{10}$in. in diameter attached to suitable supports. The collar—after seam dampening—is placed with the seam on the plate and the edge ironed and "set" by simply running a heated grooved iron over it. The ordinary type of iron is heated internally by means of a gas flame. In another form, electricity is used, while a third type is provided with an independent gasoline tank, generator, and burner. A shaping tube, fixed in a horizontal

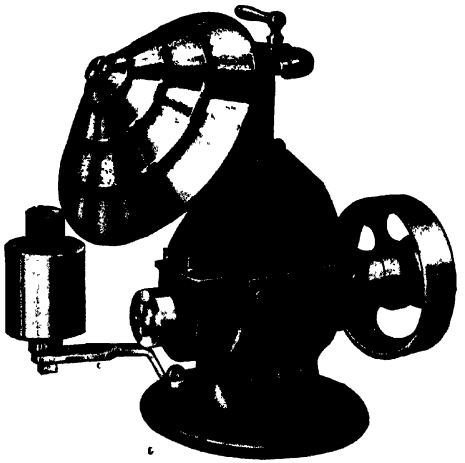


FIG. 91.—"DISC" EDGE IRONER.
(*J. Armstrong and Co., Ltd.*).

position, is usually combined with this machine; the collars are simply pushed into the tube one after another as is the case when using a vertical tube (see Fig. 93).

4.—SEAM DAMPENING MACHINES.

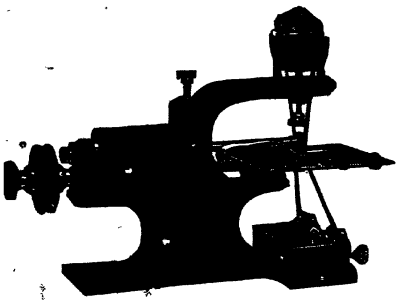
After double collars and cuffs have been ironed, they are ready for the folding operation, but, in order that this may be effected without damaging the starched linen, it is the usual practice first to moisten the goods along the seams either by means of water or steam. Seam dampening is now generally carried on automatically. One well-known form of machine consists of an iron frame supporting a flat plate or table in which is a wide opening. Working in this opening is a grooved wheel,

beneath which—and in contact with it—is another wheel revolving in a water tank. A third wheel covered with a felt or rubber band is mounted above the plate and its periphery fits the groove of the middle wheel. When it is necessary to dampen both sides of seams with this machine, the rollers are allowed to revolve in contact, from time to time, so as to moisten the upper roller. Collars are fed between the lower and central roller which may be actuated either by hand or power. The upper roller can be raised or lowered as occasion requires by means of a foot treadle.

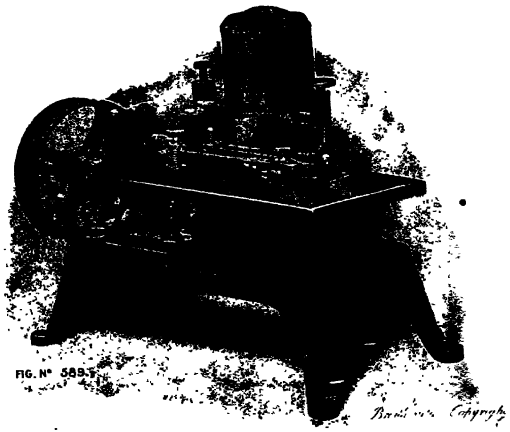
The "*Torrance*" *Seam Dampener* (Fig. 92A), represents a type of machine designed for the purpose of enabling both sides of seams to be dampened automatically at one operation. It possesses certain features which are embodied in the foregoing machine, but only two pressure wheels are employed, both of which are grooved to receive endless bands or cords. The lower cord passes over grooved moistening rollers attached to a water tank placed beneath the plate of the machine, while the upper cord is moistened in a similar manner by means of grooved rollers in an overhead water tank. Suitable guides are provided for automatically guiding the collars through the machine.

Instead of using a cord for dampening the upper roller, an arrangement similar to that shown in Fig. 92B, is frequently used, especially for very rapid work. In this, the seams are dampened by passing the collars between two milled screws, revolving in contact with one another. The lower screw works in a water tank, while the upper one is kept in a moistened condition by allowing water to drop slowly from a regulating valve attached to a container (see figure). Collar guides are attached to the plate, so that the goods have only to be fed into the machine.

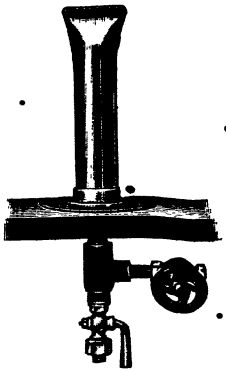
Steam is also employed for dampening purposes, as it is found to be very quick and effective, though, unless carefully used, it is apt to produce "blobby" results. A simple steam dampener largely employed is shown in Fig. 92C. It consists essentially of a steam-heated tube, flattened at one end, so that a narrow slit is left. The seam to be dampened is held by hand and passed over the slit through which ascends sufficient steam to keep it in a hot moist condition. The collar is then folded and may be shaped by holding it round the tube for a few seconds.



"Cord" Dampener.
(J. Armstrong and Co., Ltd.).



"Milled Screw" Dampener.
(I. Braithwaite and Son, Ltd.).



"Steam" Dampener.
(Cherry Tree Machine Co., Ltd.).

Fig. 92.—Various Types of Seam Dampeners.

5.—COLLAR AND CUFF SHAPING MACHINES.

"Shapers" are used for shaping and setting collars and cuffs after they have been ironed and—if necessary—folded. In one form a steam jacketed enamelled tube is fixed to a table. The collar to be shaped is inserted into the upper end of the tube, and pressed down a certain distance, thus leaving room in the top of the tube for another collar. Eventually, the tube becomes filled

FIG. 93.—"TUBE" COLLAR SHAPER.
(I. Braithwaite and Son, Ltd.).

with collars and the lowest one is then forced out and falls into a suitable receptacle placed under the table. A shaper of this kind is shown in Fig. 93.

The time required to force a collar through the tube is sufficient to thoroughly dry and shape it perfectly round. It is very useful for airing and setting collars and cuffs after they have already passed through an automatic shaping machine.

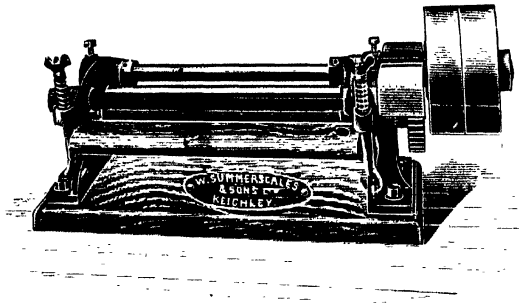


FIG. 94.—"ROLLER" COLLAR SHAPING MACHINE.
(W. Summerscales and Sons, Ltd.).

This type of shaper is largely used in conjunction with the "Shaw" edge ironer, but the tube is fixed horizontally and may be heated by any of the methods adopted for the latter. The burner employed is designed for use with any of the kinds of gas most readily available.

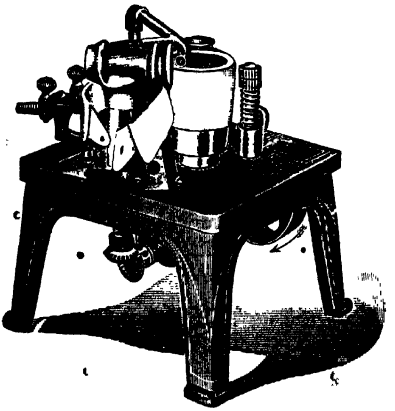


FIG. 95.—"HEIM" AUTOMATIC SHAPING MACHINE.
(I. Braithwaite and Son, Ltd.).

One well-known type of automatic shaper or curler consists of an indiarubber roller about 12 in. long by 2½ in. in diameter, and

a polished steel roller of smaller diameter (Fig. 94). The steel roller revolves at a higher rate of speed than the larger one and the pressure between them can be readily adjusted by means of springs to give any degree of curl to collars or cuffs.

"Heim" Automatic Double Collar Shaper.—This machine (Fig. 95) automatically folds, irons the seam, and curls collars

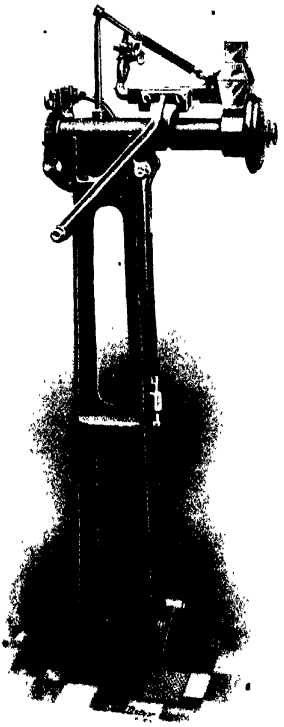


FIG. 96.—NECK-BAND IRONER.
(*J. and T. Lane, Ltd.*).

in one operation. On a suitable stand is mounted a wedge-shaped piece of iron heated by gas, a grooved wheel, and a curling spindle of special shape also heated by gas. The collar to be shaped is previously dampened at the seam on a separate machine, and fed into the shaper. It first passes over the wedge-shaped iron, which,

in conjunction with the grooved wheel causes it to assume the folded form, the seam being also ironed at the same time. The collar is then carried by means of driving bands round the curling spindle and emerges in a properly shaped condition. Many other combination folding and shaping machines are in use, but a consideration of space prevents us from describing them.

6.—NECKBAND IRONING MACHINES.

These are used for ironing the neckbands of shirts and setting them up at the necessary angle. A typical neckband ironer is shown in Fig. 96. A cast iron standard supports a narrow roller

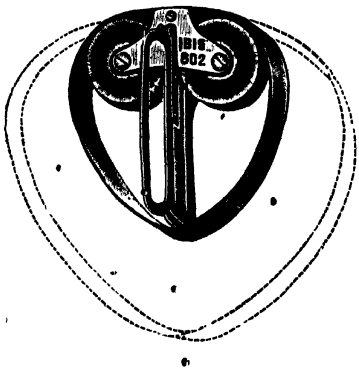


FIG. 97A.—NECK-BAND RING FOR HEART-SHAPED BANDS.

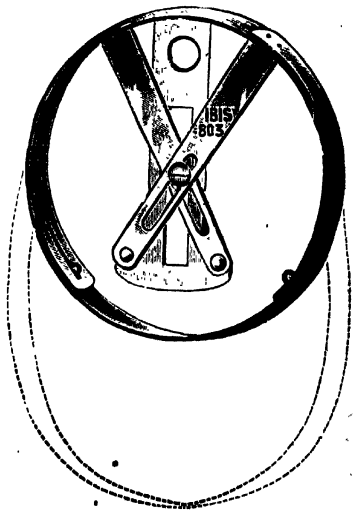


FIG. 97B.—NECK-BAND RING FOR ROUND OR OVAL BANDS.

(I. Braithwaite and Son, Ltd.).

provided with a flange on its outer edge. Above this is a hollow concave iron heated by gas. The roller is padded and is set in motion by depressing a treadle, while the same action causes the heated iron to descend and exert a varying degree of pressure upon the felt covered roller.

This machine is suitable for ironing both sides of neckbands. In another form of machine, the heated iron is replaced by

a heated polished roller. Both rollers travel at the same speed so that the neckband is not stretched. The machine is not suitable for imparting gloss to the bands, but it is commonly employed for ironing the wrist bands of shirts without cuffs.

Neckband Rings.—For "setting up" the neckbands of shirts, flexible metal rings are frequently used. These enable the bands to be finished so as to stand up straight from the bosom and yoke. They expand the neckband to the proper size without undue stretching, and are easily adjusted for different sizes of bands. Fig. 97A represents a ring for use with heart-shaped neckbands, and Fig. 97B a ring for round or oval bands.

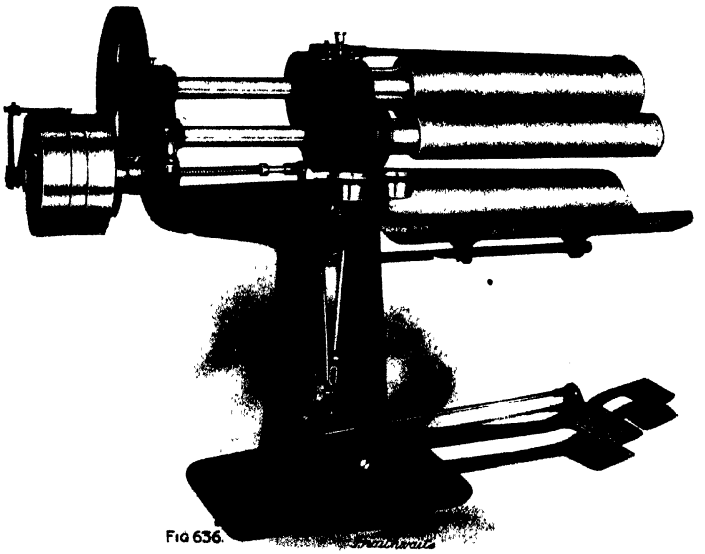


FIG. 98.—"BODY" IRONER.
(I. Braithwaite and Son, Ltd.).

In using them, a ring is placed inside the neckband, and the latter ironed with the ring in position.

3. **Ironing Machines for Body Linen, Blouses, etc.**—The ironing of such articles as aprons, shirt bodies, underwear of all kinds, skirts, overalls, etc., etc., is still done by hand in many laundries, but in large establishments special machines known as body-ironers are commonly employed as well as other labour-saving apparatus for this class of work.

Fig. 98 illustrates the ordinary type of body-ironer. Its essential features are a strong iron stand and two projecting parallel metal rollers. The top roller is highly polished and can be heated by gas, while the lower one is padded with felt. A wooden receptacle is placed immediately beneath the rollers; it is used to prevent the goods from coming in contact with the floor and dirty parts of the machine during the ironing operation.

Pressure on the treadle causes the padded roller to rise until it comes into contact with the polished roller and at the same time

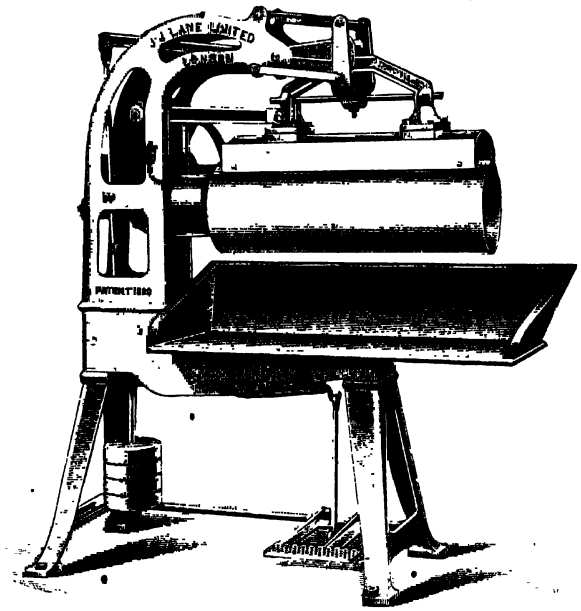


Fig. 99.—General Ironer.
(*J. and J. Lane, Ltd.*).

a rotary motion is given to the rollers by means of suitable gearing. On releasing the treadle, the rollers are thrown out of gear and the padded roller is lowered a few inches, thus enabling the operator to adjust the article being ironed while the rollers are stationary. In another type of body ironer the usual gas heated roller is replaced by a steam-heated reciprocating iron, which is shaped to fit part of the circumference of a hollow roller 12 in. in diameter. This machine is shown in Fig. 99.

PART II.

THE PRINCIPLES AND PRACTICE OF MODERN LAUNDRY WORK.

CHAPTER I.

Work of Trading Domestic Laundries.

It has been previously mentioned that commercial laundry work may be conveniently divided into three great branches, viz. :—1. Ordinary trading domestic laundry work. 2. New shirt, collar, and cuff laundry work, and 3. The laundering of new embroidered and plain soft finished goods.

The processes and materials employed in each of these branches depend primarily upon the nature and condition of the goods and the kind of finish required. Consequently, the mode of treatment to which each of the different classes of goods is subjected will be described separately.

The most important branch of the laundering industry is that in which the operations of washing and re-dressing soiled domestic articles are carried on. A considerable portion of this class of work is still done in hand laundries, but these are being gradually displaced by steam power laundries equipped with ingenious and highly efficient labour saving machines. In hand laundries, the mode of procedure is largely governed according to the kind of appliances available.

The principal processes involved in modern steam laundry work may be briefly classified as follows:—

1. Checking, sorting, and marking.
2. Washing.
3. Drying.
4. Finishing.

The washing and finishing processes include many interdependent operations, the various details of which are subject to considerable variation, not only in different laundries, but even in the same laundry, according to the kind of material to be dealt with and the machines in use. Woollen and silk goods—and in some cases those made from linen and cotton—are not starched, as this operation would degrade the soft, elastic, and other physical properties which are so characteristic of animal fibres.

SECTION I.--CHECKING, SORTING, AND MARKING.

Each parcel of goods received at the laundry is taken to the sorting room, and the various articles sorted, and checked with those already entered in the customer's book.

The sorting room should be a well-lighted and spacious apartment containing a number of bins or boxes for the purpose of holding the various classes of soiled "linen."

The marking of the goods for future identification is also done in this room.

Only one bundle or basket of dirty "linen" is opened at a time and the contents arranged in separate heaps on a suitable wooden support placed on the floor. Thus, if a bundle contains handkerchiefs, collars, and shirts, three separate heaps are made, and then by counting the number of each heap the customer's washing book is checked at once.

Instructions are given to the sorters in many laundries to place badly stained goods into a separate receptacle, so that the operator in charge of the wash-house may treat such goods for the removal of stains before they are washed. This practice has its advantages, inasmuch as it is well known that certain stains are more difficult to remove after the goods on which they occur have been washed in the usual manner, than before such treatment, and its adoption frequently obviates the necessity of a re-wash.

After sorting, the bundles are passed on to another operator who examines each article separately in order to see if it has been previously marked.

Each customer is assigned a distinctive mark, and the articles marked accordingly, either black ink or coloured cotton thread or tape being used for the purpose. Aniline black and silver marking inks are commonly employed for marking collars, cuffs, shirts, etc., while cotton thread of various colours, or tapes, are used for marking coloured and delicate articles, as well as silk and woollen goods, expensive linens, etc. Tags of aluminium covered with linen are largely used in America. They are specially adapted for goods which are simply washed and rough dried, *i.e.*, rough dry goods, and can be applied instantaneously by means of an automatic affixing machine. Brass pins with wide flat bodies upon which the numbers are stamped are also used, while machines are available for stamping the goods in plain figures or letters with ink.

Special pens, made either of glass or an alloy, are used in hand marking with ink, and it is a comparatively simple matter to

make the numbers quite plain. When coloured cotton thread is employed, however, it is necessary to adopt a system of marking in which curved letters or figures are omitted.

By using different combinations of two or more figures a very large number of distinctive marks can be obtained. The tapes frequently employed for woollens, etc., are either plain or interwoven with coloured thread in the form of numbers or letters. Plain tapes are marked with ink in the usual way.

Many different systems of marking are in use for general work, but the most satisfactory method appears to be one in which numbers are employed prefixed with the initials of the customers' surnames. In some cases a distinctive mark is used to indicate a collecting area, so as to facilitate the subsequent packing and delivery. As soon as the goods have been examined, and marked, (if necessary), they are placed in the special bins provided. From ten to twenty bins are required, varying in size according to the nature of the articles for which they are employed. The large bins are used for heavy goods such as blankets, coloured curtains, counterpanes, etc., while the smaller bins serve for the reception of the common articles of wear, and of the household.

The mode of classification of the articles in sorting is subject to wide variation in different works, but it is obviously dependent upon the amount and nature of the work in hand.

The following classification may be regarded as a typical example:—

1. Shirts.
2. Collars, cuffs, and fronts.
3. Table cloths and serviettes, *i.e.*, table "linen."
4. Body "linen."
5. Muslin and other fine articles.
6. Sheets, pillow slips, chamber towels, etc.
7. Household dusters, dirty towels, etc.
8. Curtains.
9. Coloured cotton and linen goods.
10. White and grey flannels, cricket jerseys, etc.
11. Coloured flannels.
12. Stockings and socks
13. Blankets.
14. Silk and half silk goods.

SECTION II.—WASHING.

COTTON AND LINEN GOODS.

After the articles have been sorted and marked, they are ready for the washing process, which consists of a number of operations varying in detail according to the nature of the goods to be treated.

The washing or scouring materials commonly employed are soap and sodium carbonate for linen and cotton goods, and soap and ammonia for woollen and silk goods. Special detergents are used as occasion demands. It is the usual practice to make up stock solutions of sodium carbonate and also of each of the different kinds of soap employed. The vessels used for this purpose are of galvanized iron, provided with open steam pipes for heating purposes, and taps for drawing off the liquids as required.

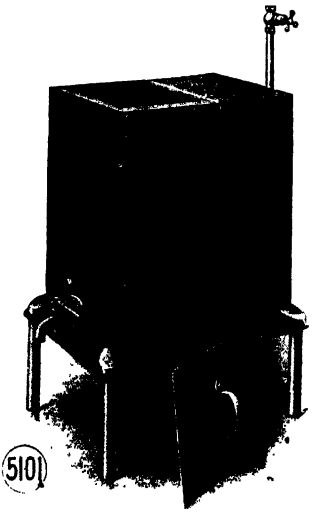


FIG. 100.—SOAP AND ALKALI CONTAINER.
(Manlove, Alliott and Co. Ltd.).

They are either rectangular (Fig. 100) or circular in shape. The following proportions may be used:—

4 oz. Stock Soda Solution.

5 lbs. 58 per cent. alkali dissolved in
20 gallons of water.

4 oz. Stock Soap Solution.—This is made by dissolving the necessary quantity of soap in water with the aid of heat and subsequently making up the solution to a definite volume, so that one gallon contains 4 ozs. of soap. If the water is hard, 1 oz. of sodium carbonate may be added to every twenty gallons with advantage before dissolving the soap.

As a general rule, it is inadvisable to employ more than two stock solutions of different kinds of soap for ordinary work. For woollens, olive oil soap is usually preferred; a stock solution may be prepared as above, using soft water and omitting the sodium carbonate. It is the practice in many works to make up combined stock solutions of soap and sodium carbonate in order to economize space and tanks. Such solutions should contain from about 2½-3 ozs. of soap and 1 to 1½ ozs. of sodium carbonate per gallon.

Although the chief operations of all washing processes are similar as regards underlying principles, they are, nevertheless, subject to considerable variation in practice. The number of operations involved; the nature and strength of the materials employed; the length of time occupied, and the actual methods adopted in carrying out the operations have all to be very carefully considered.

Heavily starched goods are subjected to a more stringent washing process than other goods, and the description given below of a typical process of this nature includes the principal features of all other washing processes carried on in rotary machines.

Washing Process for Heavily Starched Goods.—The usual process of washing collars, cuffs, etc., consists of the following operations:—

1. Rinsing in water.
2. Washing in a solution of soap and sodium carbonate at a medium temperature.
3. Boiling in a fresh solution of soap and sodium carbonate.
4. Rinsing in hot water.
5. Rinsing in warm water.
6. Rinsing in cold water.

1.—**Rinsing in Water or "Breakdown."**—The first stage of the washing process is known technically as the "breakdown." It has for its objects the removal of substances soluble in water, and insoluble surface dirt. The latter is loosened by the action of the water and is subsequently detached from the goods by means of the friction produced during the rotation of the machine. Albuminous substances, as well as perspiration and other stains

are modified and more or less completely removed in this operation. It is highly important that the temperature of the water should not exceed 110°-120° F., in order to prevent the coagulation and fixation of stains of an albuminous nature. Other kinds of stains may also be so altered—by using water at too high a temperature—*as to render them* removable only with great difficulty *in the subsequent operations.* In many laundries the "breakdown" is carried on with the aid of cold or lukewarm water rendered alkaline by the addition of sodium carbonate. This practice is undoubtedly of considerable benefit in the treatment of greasy and heavily starched goods, because in the first place, the alkaline solution exerts a slight emulsifying action on the grease, and in the second place, the starchy matter is more readily attacked. Thirdly, the removal of albuminous matter is accomplished with greater facility. The use of sodium carbonate is also of advantage if the water is hard.

The most satisfactory method of effecting the removal of old starch yet introduced, is dependent on the property possessed by the enzymes of malt of converting it into soluble derivatives. Commercial malt preparations are now being extensively used in the breakdown for this purpose; their employment in the latter operation, as well as in other ways, will be more fully discussed when dealing with examples of processes. It may be noted here, however, that they are useless in presence of alkalies, so that their employment in the breakdown should always be preceded by a short agitation of the goods in warm neutral water, in order to ensure the more or less complete removal of traces of alkali which are commonly introduced with the starch mixtures used in finishing.

In parts of France and other European countries, the first part of the washing process consists of a steeping operation, the goods being allowed to remain in water or weak soap liquor overnight. By adopting this method, the starchy matters and many other substances are rendered soluble to a greater or less extent, by complex fermentative changes, before the actual washing begins. It is much slower, however, than the rotary machine method, and more space is required, but on the other hand the "linen" is said to last longer.

The amount of sodium carbonate added to the water for an alkaline breakdown depends principally upon the hardness of the water and the nature of the goods to be washed. As a rule, it is unnecessary to add more than $\frac{1}{16}$ oz. of anhydrous sodium carbonate to each gallon of water. The hot water required for the various washing operations, as well as for general purposes, is

supplied from a covered tank placed in a suitable position at a high level, the water being kept hot by means of a circulating system in which the exhaust steam from the engine is fully utilised. A floating valve is usually fixed to the cold water inlet, so as to ensure a regular and automatic supply of hot water; the outlet pipe should be fixed in the side of the supply tank near the top, in order to prevent solid matter from being carried into the washing machines.

Fig. 101 represents a system of this kind designed by Royles Ltd. The exhaust steam from the engine passes directly into the top of the heater—which is shown partly in section—and thence in a downward direction through a series of Row's patent indented tubes, round which the water to be heated circulates.

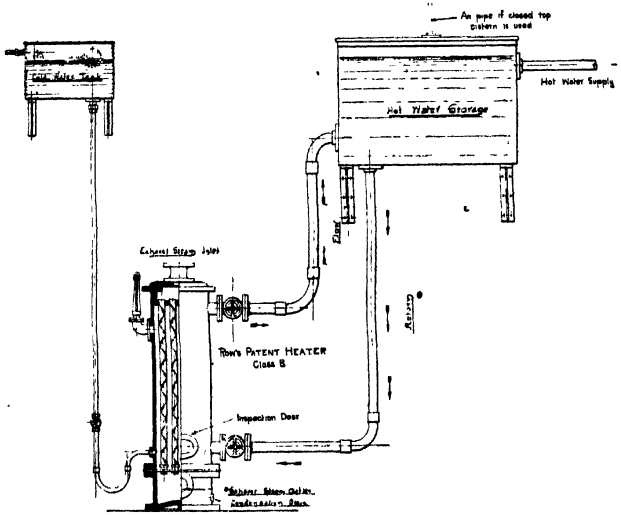


FIG. 101.—CONTINUOUS HOT WATER SUPPLY SYSTEM.
(Royles Limited.).

Condensed steam passes away at the bottom. The construction of the heater is such that the body may be readily disconnected and hoisted clear of the tubes, leaving the latter fully exposed for inspection and cleaning when required; it may thus be used with hard water depositing scale. The mode of circulation of the water is clearly shown in the diagram.

Breakdown.—Mode of Procedure.—The hot and cold water valves are opened, and if the supply pipes have not been used for

some time, it is advisable to allow a quantity of the water to run to waste, owing to the danger of introducing iron rust into the machine. The outlet valve is then closed and the water run into the machine, the amount of hot and cold being so regulated that the temperature of the liquid when ready for use is about 100°F.

The volume employed should be sufficient to reach half way up the gauge glass, but half of this is enough both for the first and second suds. Cold water only, is usually run into the machine in the case of an alkaline breakdown, and the necessary quantity of sodium carbonate solution is then added. The soiled "linen" is next introduced and the machine set in motion and run slowly for about ten minutes. The waste water is then removed and the goods are ready for the next operation.

It has been already stated that when sodium carbonate is added to hard water, insoluble carbonates are usually precipitated, and it is conceivable that under the conditions of laundering practice, the precipitation of insoluble matter may take place in each fibre.

If it were always practicable to add the sodium carbonate to the water before the introduction of the "linen" at each stage of the process in which alkali is used, precipitation within the fibres would either be entirely prevented or at any rate considerably diminished. This mode of procedure, however, is only practicable in the breakdown, because its adoption in all cases would necessitate the removal of the "linen" from the machine and its subsequent re-introduction at each of the stages immediately preceding the alkaline treatments. Of course, if the water in use has been properly softened, no precipitation should take place on the addition of "alkali." The complete removal of insoluble carbonates from fibres which have been contaminated in this way, can only be properly effected by subsequently impregnating the articles with a suitable acid. Hence, a custom has arisen of rinsing the goods in an acid during the final stages of washing. Most authorities who have studied the matter, are agreed that vegetable fibres are frequently rendered harsh and their tensile strength considerably lowered by subjecting them to pressure at high temperatures, *e.g.*, the ironing process, when contaminated with inelastic inorganic matter, such as calcium carbonate. This is brought about by the friction set up between the inorganic matter in the individual fibres, the fibres themselves, and the surfaces of the ironing machines.

Insoluble matter which may have been used in previous finishing operations for "filling" purposes, is removed more or less completely by the rubbing action of the articles upon each other during the rotation of the machine.

2. **Washing with Soap and "Alkali" at a Medium Temperature.**—This operation, commonly known as "first wash" or "first suds," immediately follows the breakdown. Its chief object is to effect the removal of substances which are readily emulsified by soap solution at a medium temperature, any loosely adhering dirt being carried away in the emulsion. Traces of non-coagulated albuminous matter which have escaped the breakdown are also removed, while the soap solution employed easily penetrates and lubricates the individual fibres, thereby reducing the friction between the goods during the rotation of the machine.

It is generally admitted that the cleansing action of soap in the "first suds" as well as in other washing operations is of a highly complex nature, and for more than a century, the elucidation of the problem has been the subject of numerous investigations by various chemists. We give below a short account of the more important theories advanced.

Detergent Action of Soap.—The mode of action of soap solution in removing dirt from textile and other materials has been explained in different ways. One of the oldest explanations is that hydrolysis occurs when soap is dissolved in water and the alkali thus liberated immediately attacks any grease on the surface of the material to be cleansed. Berzelius and Chevreul held this view.

Rotondi, (*Jour. Soc. Chem. Ind.*, p. 601, 1885), considered that the grease is saponified by a basic soap which he believed to be formed by hydrolysis.

Hillger, (*Jour. Amer. Chem. Soc.* p. 524, 1903), maintains, however, that both these theories are illogical, inasmuch as the free alkali or basic soap liberated according to the first and second theory respectively, would have a far greater tendency to react with the acid part of the soap with which it was originally combined, than to saponify a neutral fat.

Another argument put forward against the above theories is that hot strong soap solutions possess greater detergent properties than weak cold solutions, although it is well known that the latter are more readily hydrolysed than the former. Consequently, it is concluded that the detergent properties of soap solutions are not dependent upon the presence of products of hydrolysis.

The most satisfactory theory yet advanced is based upon the well-known property of soap solution of readily forming emulsions when shaken up with oils and fats.

Hillger has shown that this property is not due to the presence of alkali in the soap solution as was formerly supposed, but is a property possessed by the soap alone. It was found that no

emulsion is produced when a weak solution of caustic soda is shaken up with neutral cotton-seed oil; but if an oil containing free fatty acids is used, an emulsion is readily formed. Further, no emulsion is obtained with a weak alkali and kerosene, whereas a solution of a neutral soap, (sodium oleate), gives an emulsion both with kerosene and with neutral cotton-seed oil. From these and other experimental observations, Hillger concludes that the detergent properties of soap solutions can best be explained by their power of emulsifying grease, of readily penetrating fibrous materials, and of lubricating surfaces and impurities, so that the latter become less adherent to the materials and are easily removed.

The physical properties of soap solutions have also been exhaustively studied by several investigators and from the results obtained, various explanations have been offered in order to account for the detergent property of soap. Careful experiments have shown that the surface tension of soap solution is only about two-fifths of that of water, while its cohesion is also comparatively low, and it appears highly probable that the value of soap solution as a cleansing agent is dependent upon these properties to a greater or less extent.

An important contribution to our knowledge of the subject has recently been made by Spring, (*Jour. Chem. Soc.* 1909, A. 1,628), who maintains that the theories hitherto advanced are inadmissible, as they seek only to explain the removal of greasy impurities.

Some interesting experiments were made with soap solution and lamp black. It was found that when purified soot is shaken up with a 2 per cent. soap solution, it is deposited almost as rapidly as from pure water, while with a soap solution containing less than 0.5 per cent. of soap, deposition requires about ten days. With a 1.0 per cent. solution, the soot is not completely deposited after two months, thus showing that a solution of soap of a certain strength exists which is best adapted for retaining soot in suspension.

If the soap solution containing soot in suspension is filtered through ordinary filter paper, (cellulose), the paper is not even blackened, but when pure water containing soot in suspension is filtered, the soot remains on the filter paper.

This behaviour is said to be due to the formation of a soap-soot colloidal compound in the first case, and a colloidal compound of cellulose and soot in the second case. The former is considered to be more stable than the cellulose-soot compound, inasmuch as the latter is not formed when soot suspended in soap solution is filtered.

Analysis of the soap solution from which soot had settled, showed that the original soap solution had been decomposed into a basic soap and an acid soap, and that the soot had formed an absorption compound with the latter. The soot-acid-soap compound was found to have no power of adhesion to objects in water, such as skin, paper, wood, glass, etc. Cellulose also decomposes soap solution, but it fixes a basic soap, thus differing from soot.

From the above results it is concluded that separation of soot (dirt) from cellulose ("linen") is dependent upon the affinity of the former for acid soap and of the latter for basic soap, so that in the washing process basic soap is substituted for the dirt on the "linen." Thus if O represents the object defiled by the dirt D, and S is the soap, we have:—OD+S=DS+O, *i.e.*, a simple example of substitution.

It is interesting to note that alcoholic soap solutions do not form colloidal compounds with soot; and as it has long been known that such solutions lack cleansing properties and are very stable when compared with aqueous solutions, it would appear, as if, after all, hydrolysis plays a not unimportant part in connection with the cleansing power of soap.

Other experiments were made by Spring with red ochre, clay, and silica, and the results obtained serve to confirm the conclusions already given as to the general mode of action of soap solutions.

"*First Suds.*"—*Mode of Procedure.*—After the waste water from the breakdown has been run away, fresh cold water is introduced into the machine. Its volume or height as indicated by the gauge glass should be so regulated that the goods are just covered. Sodium carbonate stock solution is next added, the quantity depending upon the nature of the goods and the degree of hardness of the water. For comparatively clean goods very little soda is necessary. Indeed, it is customary in many laundries, only to add sodium carbonate when hard water is used, in order to effect economy in soap consumption by preventing its decomposition in presence of lime or magnesium salts.

It will be evident from this statement that the sodium carbonate should always be added to the water before the soap liquor.

A sufficient quantity of the stock solution of soap is next added, the particular soap used being dependent upon the nature and condition of the "linen." It is impossible to give here the exact quantities of soap to use for the different classes of goods, since so much depends upon the amount of fatty matter in the soap used, the condition of the goods in hand and their weight.

In a few laundries the amounts of soap and soda employed are based upon the approximate weights of the different batches of goods. This method is an excellent one and appears to be finding favour amongst up-to-date launderers. It is undoubtedly more economical and ensures more uniform results than the usual guess work practice of adding sufficient soap to yield a good lather. On the other hand, however, it is only possible to introduce a satisfactory system of this kind by making a large number of careful observations during the washing of batches of different classes of goods and checking each fresh delivery of soap by chemical analysis. Still, when once such a system has been established and a reliable series of figures obtained for goods in different states, it will be evident that the success of a washing process will be less dependent upon the skill and judgment of operators who may prefer to work by noting the amount of lather produced.

The exudation of the latter over the sides of the machine is considered to be an indication that too much soap has been added. On the other hand, the presence of a sufficient amount of suds throughout the whole of the process is an essential factor in the production of satisfactory work.

The first suds is not always carried on as a separate part of the washing process, but it is typical of the usual procedure in the treatment of collars, cuffs, and other heavily starched goods.

Slightly soiled goods containing only a small amount of starch are subjected to the usual breakdown, but they are only washed once with soap and soda, the temperature being gradually raised to the boiling point. The length of time occupied in the first suds varies in different laundries, but from 15 to 20 minutes is the average, the temperature of the liquor being gradually raised to 140°-160° F.

3. **Boiling with Soap and "Alkali."**—This operation is frequently known as "second suds," "second wash" or "boil." As soon as the first suds operation is finished, the waste liquor is removed, and fresh water at 100°-110° F., introduced into the machine. It may be mentioned that it is undesirable to subject textile materials to sudden and wide changes of temperature, as the practice is liable to result in a gradual weakening of the fibres. Apart, however, from this danger which is frequently ignored, there may arise defects in the form of stains, caused by the precipitation of greasy matter in combination with dirt. Consequently, cold water should not be added to hot goods, especially if the latter are impregnated with soap.

In some cases, the goods are given a rinse in warm water after the first suds, and then fresh warm water is introduced.

Steam is next admitted, and the temperature slowly raised to the boiling point, soap and sodium carbonate having been previously added according to requirements. A treatment of about 10-15 minutes at the boil suffices for the majority of goods, the whole operation being completed in from 20-30 minutes.

The object of the second suds is to effect the emulsification of traces of greasy matter which have resisted the action of the soap and soda more or less completely in the previous operations. As a result of this action, the dirt associated with the grease is liberated and mechanically removed from the goods during the revolution of the machine. Starch on heavily starched goods is more readily removed in this operation than in the breakdown or first suds, owing to the energetic action of the boiling alkaline solution.

The emulsive properties of the soap, as well as the friction produced during the process are also of the highest importance in bringing about the complete removal of the last traces of impurities.

A bleaching operation is frequently carried on in conjunction with the second wash. In this case, a small quantity of the bleaching solution (which usually consists of sodium hypochlorite), is added directly to the contents of the machine.

Bleaching powder solution cannot be used in presence of soap, as double decomposition would occur, resulting in the precipitation of insoluble lime soaps.

4. **Rinsing in Hot Water.**—The waste liquor from the second suds is removed as soon as the operation has been carried on for the necessary length of time. Hot water is then introduced into the machine in sufficient quantity to immerse the goods completely, and the rinsing continued for about 5-10 minutes, the waste liquor being removed as before. It is highly important to use hot water in the first rinse, in order to remove more effectually, the soapy emulsion containing the impurities, with which the goods are contaminated. We have already referred to the defects likely to be produced if cold water is allowed to come into contact with goods impregnated with soap-dirt emulsions. Furthermore, defects which are caused by the presence of precipitated matter can only be satisfactorily remedied by subjecting the goods to an acid treatment followed by a re-wash.

5. **Rinsing in Warm Water.**—In this operation the goods are rinsed in fresh warm water for a few minutes, whereby traces of impurities left from the first rinse are removed. The goods are cleansed more effectually by the use of warm water, while at the same time sudden changes of temperature are avoided. It is ad-

visable to test the rinsing water with red litmus paper in order to make sure that all traces of alkali have been removed, *i.e.*, if the acid bath is not employed.

6. **Rinsing in Cold Water.**—This is the final operation in washing, the goods being simply agitated for a few minutes in cold or lukewarm water. Cold water rinsing is usually carried on in conjunction with blueing, in which case the requisite amount of "blue water" is added to the contents of the machine.

SECTION III.—AUXILIARY OPERATIONS.

In ordinary laundering practice, it is an almost universal custom to carry on various auxiliary operations during the washing process commonly adopted for linen and cotton goods, and we may enumerate them as follows:—

1. Acid treatment.
2. Bleaching.
3. Blueing.
4. Starching.

1. **The Acid Treatment.**—It has been stated in a preceding paragraph that insoluble carbonate of calcium may be formed in the fibres of the "linen" during the washing process, and in order to effect its removal many launderers use what is known as the "acid bath," which merely consists of a weak solution of a suitable acid, in which the goods are agitated for a few minutes. The best acid to use is acetic, because it not only forms readily soluble salts with most metals, but it has practically no action on the "linen" or on the metal machines into which it is frequently introduced.

In addition to its use for the above-mentioned purpose, the acid bath is of the greatest importance for effecting the neutralisation of traces of alkali which have not been removed during the previous rinsing operations, the products consisting of a very soluble salt and water.

The chemical changes occurring in these reactions may be represented by means of the following equations:—

$$CaCO_3 + 2C_2H_4O_2 = Ca(C_2H_3O_2)_2 + CO_2 + H_2O$$

Calcium carbonate + acetic acid = calcium acetate + carbon dioxide + water.

$$Na_2CO_3 + 2C_2H_4O_2 = 2NaC_2H_3O_2 + CO_2 + H_2O$$

Sodium carbonate + acetic acid = sodium acetate + carbon dioxide + water.

All soap must be thoroughly removed from the goods before they are allowed to come into contact with the acid. The

strength of the latter should be about ½-1 per cent., *i.e.*, ½ to 1 lb. of the commercial acid to every 10 gallons of water, and the goods should be agitated in the liquor for about 3-5 minutes immediately after the second rinse. The acid is then discharged and the goods given a thorough rinse in cold water. They are then blued. When basic or acid coal-tar dyes are used for blueing, the dye solution may be added to the weak acid liquor, thus dispensing with the intermediate rinsing operation. Although, as stated above, weak acetic acid has practically no effect upon iron during the short time it is in contact with the machine, nevertheless, it exerts a slight action on the insoluble soaps with which the inside of the machine is frequently coated. In this case, the acid causes a more or less complete decomposition of the soaps—according to its strength and temperature—with the formation of metallic acetates and fatty acids. The former, being soluble in water, are easily removed, but the latter are deposited upon the fibres and may ultimately give rise to stains. In exceptional cases it is necessary to remove the liberated fatty matter by emulsification with soap and "alkali," *i.e.*, by a re-wash.

If sufficient space is available, the acid treatment is best conducted in separate wooden tanks. This mode of procedure, however, obviously incurs additional labour, and is not likely to be adopted to any great extent. In any case, it is essential that the goods be kept in motion during the subsequent blueing operation, so as to prevent unequal absorption of the blue. Hence, it is customary to blue most goods in the rotary machine, whether they have been subjected to an acid treatment in tanks or not.

2. **Bleaching.**—It is by no means an infrequent occurrence to find that many goods which have undergone the ordinary washing process, are not white enough to be sent forward to the finishing departments. The parts of collars which have been in contact with the skin, commonly exhibit a yellowish colour, and washing in solutions of soap and sodium carbonate has little effect. Similarly, many stains on table linen and other goods cannot be removed by means of soap and soda. Hence, as the individual examination and local treatment of all articles in the "wash" is not feasible, a custom has arisen, whereby the whole of the contents of the machine are subjected to a mild bleaching operation as occasion demands, a solution of sodium hypochlorite being generally employed for the purpose. The latter may be prepared electrolytically from common salt, or by mixing solutions of sodium carbonate and bleaching powder, as described on page 67.

Solutions of bleaching powder, *i.e.*, calcium hypochlorite, are used in some laundries, but these differ from solutions of sodium

hypochlorite in that they form precipitates with soap. Thus, they can only be used in separate baths, whereas it is the invariable custom to add the sodium compound directly to the contents of the machine during the second wash. The reasons put forward for this departure from the recognised method of using hypochlorite solutions in textile bleaching, *i.e.*, steeping in cold solutions, may be stated as follows:—

1. The method is simple and does not interfere with the ordinary washing process in machines.
2. A saving in time and space is effected.
3. The bleaching solution—when mixed with the wash liquor—is so weak that it would have little effect in the cold, but it is strong enough to bring about the desired result at a higher temperature.
4. If a cold solution were employed, it would have to be much stronger in order to give the same results in a reasonable time, and its application would necessitate considerable waste if the operation were carried on in the washing machine.
5. Many stains which are apparently unaffected in the presence of cold sodium hypochlorite solution, are removed more or less readily when treated with a warm solution.

This custom of bleaching in conjunction with the washing process has now become quite general. In some laundries the operation is carried on in the first instead of in the second wash, while in others it is customary to bleach in the first hot rinse or in the second rinse. In the two latter cases a hot rinse follows the bleaching operation and then a rinse in weak acetic acid followed by another rinse in cold water.

The defects which are liable to arise from the use of warm hypochlorite solutions are:—

1. Diminution in the tensile strength of the goods.
2. A harsh and unpleasant "handle."
3. A bad colour.

Diminution in tensile strength may be brought about gradually by subjecting goods to a weekly bleaching operation at a comparatively high temperature whether necessary or not, or by using too much of the stock solution at each operation. The omission of an acid treatment after bleaching, and neglecting to wash the goods thoroughly, induce the degradation of those physical properties, *e.g.*, colour, handle, etc., upon which the value of vegetable fibres depend.

The volume of sodium hypochlorite required for the treatment of a definite quantity of goods, depends upon the percentage of available chlorine present in the solution, the condition of the goods, and their approximate weight. Twaddell's hydrometer is generally used for the purpose of ascertaining the strength of the solution, but this mode of testing is by no means reliable, since the degree registered by the hydrometer is not a measure of the amount of available chlorine present, but simply indicates its specific gravity. So long, however, as the solution is made in exactly the same way from bleaching powder and sodium carbonate of known strength, and the stock solution obtained tested with a reliable hydrometer, the results will be quite satisfactory. This statement does not apply in cases where standing bleach baths are used.

Whenever a weak solution is required, it is only necessary to make a simple calculation and to dilute with water accordingly. For instance, if it were desired to make a solution of sodium hypochlorite to indicate 2° on the hydrometer, and the stock solution indicated 12°, it would only be necessary to take 2 parts of the stock solution and dilute with 10 parts of water. This plan is essential when very weak solutions of known "strength" are required, *i.e.*, if a chemical method of checking the strength is not employed. If the bleaching solution be made as required by the electrolysis of brine of constant strength and with the aid of a current of known voltage, it will be found that the amount of active bleaching agent contained in a definite volume of the electrolysed brine will vary only to a small extent from day to day. It is highly important, however, to adopt a definite chemical test when valuing a solution prepared in this way.

All hypochlorite bleaching solutions are unstable and become weaker in bleaching properties when exposed to the air, but for all practical purposes in the laundry, the slight diminution in strength of sodium hypochlorite—prepared from bleaching powder and "alkali"—which takes place under the above conditions is of no consequence.

In bleaching with chlorine compounds in the cold, it is well known that some of the decomposition products as well as traces of the original substances are retained by fibrous materials with great tenacity, and fibres contaminated in this way are liable to become tendered or discoloured during the subsequent operations or on storing. It is highly desirable, therefore, to subject goods which have been bleached with hypochlorites under these conditions to an acid treatment, in order to ensure the complete decomposition of all traces of the bleaching solution and the removal of the resultant products.

When a hypochlorite is used in the laundry, however, it is maintained that the usual conditions under which its action is utilised, *i.e.*, at a comparatively high temperature in presence of "alkali," are such, that it is practically impossible for traces of the original liquid or its decomposition products to be left in the fibres. This view is undoubtedly correct, inasmuch as it is inconceivable that an extremely dilute solution of sodium hypochlorite can withstand a boiling temperature for a considerable length of time in presence of oxidisable matter, without undergoing complete decomposition, even though the solution be strongly alkaline.

It is not the general practice, therefore, to use subsequently an acid bath, simply because the goods have been bleached in the "wash" or first hot rinse. Indeed, it may be here remarked, that the advantages claimed in a previous paragraph for the acid treatment of goods which have not been bleached during the washing process, have not been recognised to any great extent in modern laundering practice.

There is no doubt, however, but that its adoption is of the greatest utility, especially in view of the fact that there is a general tendency amongst launderers to shorten the rinsing operations as much as possible, thus deliberately favouring the development of those defects, for the prevention or eradication of which, it is advocated.

The bleaching action of sodium hypochlorite under the conditions which obtain in the second wash may be explained briefly by assuming that the main chemical change is brought about by hydrolysis, whereby hypochlorous acid is liberated and immediately decomposed in presence of oxidisable matter, with the evolution of nascent oxygen, thus:—

(1). $NaOCl + H_2O = NaOH + HOCl$.

(2). $2HOCl = 2HCl + O_2$.

Many other minor chemcial changes take place at the same time, but these do not, as a rule, influence the final result given above, except in so far as its retardation or acceleration is concerned.

With regard to the frequency of the bleaching operation in conjunction with the second wash, obviously, everything depends upon the state of the goods and the judgment of the operator, but, if the washing process is carried on according to the particulars already given, and special attention is paid to the rinsing operations, there should be no necessity to bleach such goods as collars, cuffs, etc., more than once in every three or four weeks, although table "linen" may need a mild bleach every week, according to its condition, *i.e.*, whether heavily stained or not.

In washing and bleaching expensive linen and cotton goods, great care is necessary in order to ensure the complete elimination of all traces of chlorine, and with this object in view, substances termed "antichlors" are sometimes employed.

The chief antichlors are sodium bisulphite and sodium thiosulphate. They dissolve readily in water and react chemically with chlorine, forming soluble products which are without detrimental effect upon the vegetable fibres.

A ½-1 per cent. solution in cold water of either of these substances is strong enough. A little acid may be added to the former with advantage. The goods—after bleaching and washing—are steeped in the cold weak solution of the antichlor for a few minutes, squeezed, and finally thoroughly washed.

An interesting and important addition to the list of bleaching agents suitable for laundry work has been recently introduced under various names. This new product is known chemically as sodium perborate, and may be used in the wash along with the soap. It yields excellent results and there is very little danger of the goods being tendered by its use. It is already finding extensive application in steam laundries, as it effectually bleaches the yellow stains on collars due to human perspiration. The white obtained with sodium perborate is permanent, and is quite equal to the white obtained by the use of any other bleaching agent.

An account of its mode of employment is given under "examples of washing processes."

3.—**Blueing.**—This auxiliary operation of the washing process has for its object, the masking of the yellowish appearance exhibited by nearly all "white" textile articles after treatment with alkaline detergents. The theory underlying the use of blue as a corrective of the yellow tint of fibres can be best explained by first considering the nature of the blues employed, and we may here broadly distinguish between insoluble and soluble blues. Practically all soluble blues possess the property of staining vegetable fibres, when the latter are agitated in a weak aqueous solution, but the amount of colour taken up is entirely dependent upon the nature of the blue. In the actual operation of blueing, only the slighest possible tint is required, so that soluble blues which are of no use from the cotton and linen dyer's standpoint, may often be employed with success in the laundry.

Insoluble blues occur in a very fine state of division and are deposited on the fibres in this form. Ultramarine and smalts are the chief representatives of the latter class, while the soluble blues are either coal-tar dyes, indigo derivatives, or mineral colours held in solution by other chemicals.

When ultramarine or smalts is used for blueing, a vast number of infinitesimal particles of insoluble blue are deposited on the surfaces of the materials, but they are not deposited close enough to prevent the reflection of some of the yellow colour of the fibres, with the result, that a mixture of blue and yellow light is reflected. When blue and yellow light are mixed in proper proportion, however, the sensation of white is produced, hence, bleached fabrics treated with the necessary amount of such a blue exhibit an appearance which is far more pleasing to the eye than the original yellowish colour.

Excess of blue causes the fabrics to assume a bluish tint, while insufficient, causes them to exhibit an inferior white. The theory outlined above is dependent upon the addition of coloured lights, but in considering the theory of the action of soluble blues in yielding similar results, we are concerned with the subtraction of light. It is well known that a blue added to a yellow produces a green, and if we examine the spectra of all blues and yellows which produce greens on being mixed, it will be found that a greater or less amount of the green portion of the spectrum is transmitted by each. In other words, most blues and yellows are transparent to green light, so that the latter is the light reflected when they are mixed. If we add a blue which does not transmit the green part of the spectrum to a yellow, however, the resultant colour will be black, or grey provided the solutions are very weak, and this result explains the action of soluble blues in neutralising the yellow colour of fibres. It will be evident from the above remarks, that the best blues to employ in the laundry are those which are opaque to green light, or in other words they should be transparent to those parts of the spectrum which are opaque to yellow. Pure blues possessing these qualities are rare; most of them transmit a greater or less amount of green. In practice, however, it is the custom to use red shades of blue, *i.e.*, violets, because these transmit only a little of the bluish green in addition to red, blue, and violet.

We must assume that the yellow of fibres transmits red, orange, yellow, and green. Therefore, on mixing two colours of this nature, *i.e.*, yellow and violet, in the right proportions—or if we dye a yellowish fabric with a very weak solution of the violet, a grey, *i.e.*, a mixture of black and white, is produced, because, although both colours transmit red, part of it is neutralised by the greenish blue of the violet, and the remaining portions of the spectrum of the latter are opaque to the spectrum of the yellow. Thus, no colour is reflected

Blueing.—Mode of Procedure.—Goods which have been washed in rotary machines are usually blued before removal, but special articles are blued by hand in a suitable wooden vessel, and subsequently passed between the wooden rollers of a wringing machine to remove excess of water. If ultramarine blue is employed in the operation, the requisite amount is weighed out and placed in the centre of a piece of fine calico. The corners of the latter are then gathered together in the hand and the whole agitated in warm water contained in a pail until most of the blue has passed through the material. By adopting this method, impurities are removed and the blue particles suspended in the water are in an extremely fine state of division, a condition which is essential for the production of uniform tints on textile goods.

The "blue water" in the pail is then added to the contents of the washing machine during the last rinse, and during the time that the inner cylinder is revolving towards the operator. If the blue be added while the cylinder is revolving in the opposite direction, it is distributed unequally upon the goods, thus giving rise to "patchy" effects.

The amount of blue to be used can only be ascertained by practice, because not only does the nature and the amount of the goods in the cylinder vary from time to time, but the colouring powers, and shades of commercial ultramarine and other blues are also subject to considerable variation.

When liquid blues are employed, it is only necessary to add the requisite volume diluted with water to the contents of the machine.

It is often found that goods which have been blued, are either too blue, or exhibit a greenish, or slate tint. In this case advantage is taken of the fact that ultramarine blues are readily decolourised in presence of acids, while "Prussian blue" is decolourised by means of alkalies. An objectionable tint due to the use of the former may be removed, therefore, by agitating the goods for a few minutes in a warm solution of oxalic or other suitable acid of a strength of about 1-1½ ozs. per gallon, a 1% solution of sodium carbonate being used for the removal of a bad colour caused by the use of "Prussian blue."

The primary cause of the green or slate tint referred to above, is a defective washing process, in which the use of too much "alkali," and insufficient soap, as well as insufficient water for rinsing purposes, are the main features. It is well known that the frequent treatment of cotton and linen goods with hot alkaline solutions gradually causes them to assume a more or less pronounced yellow or brownish colour. The production of in-

soluble soaps by the use of hard water, also accentuates this defect, as such substances may contaminate the materials under treatment and become discoloured by oxidation induced by the subsequent ironing process. An insufficient amount of soap in the washing operation contributes towards the production of a bad colour by "setting" the dirt and grease in the fibres of the materials, while the incomplete removal of traces of alkali, or of soapy emulsions containing the various impurities, originally present on the goods in suspension, are also contributing causes. If, however, the yellow tint is comparatively slight, no difficulty is experienced in masking it with the aid of a suitable blue. On the other hand, if a fabric acquires a distinct yellowish tint during the washing process, it is found in practice, that the subsequent blueing operation causes the material to exhibit a blue, green, or slate tint. The bluish tint is caused by the use of too much blue, the green tint by the use of insufficient blue, or by the use of an unsuitable variety, and the slate tint by "neutralising" the yellow with the correct amount of a suitable blue.

It is evident, from the above statements, that, if the yellow colour of the fibres is too pronounced, a perfect white cannot be obtained by blueing.

As previously mentioned, the blues employed for correcting the yellow tint of the fibres should not possess a greenish hue, since such blues are apt to impart a green tint, even to those fabrics which have been washed by methods which are in accordance with the best modern practice.

In the United States of America, insoluble blues are rarely used, preference being given to soluble blues derived from coal tar. Many dyes of this nature—especially those known as basic dyes—are partially precipitated from their solutions when brought into contact with water containing calcium and magnesium carbonates in solution, *i.e.*, hard water. In order, therefore, to overcome this objectionable feature—which may cause the blue to be deposited on the goods in specks—it is the general custom to add a little oxalic acid to the first rinsing water immediately before the addition of the solution of blue, so that the calcium salts are converted into insoluble oxalates, which apparently have no action on the dyes used. The acid also serves for the purpose of neutralising traces of alkali, while iron compounds are dissolved; consequently there is much less danger of the goods acquiring a bad colour during the subsequent operations.

If an acid dye is employed, acidulation of the water is necessary in order to liberate the colouring principle of the dye. Alkali blues are used along with soap and the colour subsequently

developed in the acid bath. A hot rinse should always be given to vegetable fibres after treatment with oxalic acid, and this should be followed by two cold rinses. The amount of acid employed varies from about 1-2 ozs. per 10 gallons of water and the time occupied from about 3-5 minutes.

4. **Starching.**—It is now an almost universal custom in power laundries to starch certain classes of goods in the washing machine during the last rinse. This practice obviates the necessity of a subsequent starching operation in a special machine, and is especially suitable for the treatment of such goods as table cloths, serviettes, and other articles which do not need to be very stiff, but yet require to be impregnated with a small amount of starch in order that a certain finish may be imparted during the subsequent ironing processes. Collars, cuffs, and shirts, are frequently treated with weak boiled starch in the washing machine previous to the main starching operation.

The starch commonly employed is either maize, rice, or farina, according to the quality of the goods to be treated, and the nature of the "finish" required. It is mixed with the necessary quantity of cold water, and then boiled up in a suitable vessel, after which it is added to the contents of the machine. If the paste thus obtained is not perfectly smooth, it should be filtered through a piece of calico.

In some works it is customary to add a small quantity of one of the numerous proprietary "glazes" to the starch paste; a good quality of curd soap, however, gives good results. The approximate amounts of the ingredients required for starching a load of table "linen" in a 100-shirt machine, the water being in sufficient quantity to allow the goods to be impregnated in a uniform manner, are as follows:—

1-1½ lbs. rice, maize, or potato starch, 2-3 ozs. "glaze," 3 gallons of water.

The "glaze" used should be readily miscible with the starch mucilage. It may be omitted, and soap used instead.

The actual starching operation is conducted as follows:—After the blue has been added in the last rinse, the machine is allowed to run for a few minutes; the outlet pipe is then opened for a short time in order to remove excess of water and the thin boiled starch introduced into the machine, which is kept in motion for about 3-5 minutes. The goods are then ready to be removed.

In order to obtain concordant results with different batches of similar articles, it is very important that the boiled starch should not be unduly diluted or used too strong; consequently,

the volume of water contained in the machine before the starch paste is added, should remain constant for equal weights of different batches of the same class of articles. Furthermore, it is necessary to use warm water when starching in this way.

SECTION IV.—EXAMPLES OF PROCESSES.

In the following pages a series of typical examples is given to illustrate modern methods of washing the different classes of cotton and linen goods in rotary machines.

The approximate amounts of soap and "alkali," etc., given in each example are for a full load in a 100-shirt machine.

Collars, Cuffs, and other Heavily Starched Goods.

Example 1:—

1. Breakdown for 10 minutes using warm water; remove dirty liquor.
2. First suds. Use cold water, and add 1 gallon stock soda solution (4 ozs.), and 3 gallons stock soap solution. Run machine 15-20 minutes, gradually raising temperature of liquor to 140°-160° F Remove waste liquor.
3. Second suds. Use warm water, add ¾ gallon stock soda solution and 2 gallons stock soap solution. Bring liquor to boil in about 10 minutes and boil 10 minutes. Remove waste liquor.
4. Rinse in hot water for 3-5 minutes.
5. Rinse in warm water for 5 minutes.
6. Rinse and blue—if necessary—in warm or cold water.

Example 2:—

1. Breakdown for 5 minutes in cold water containing ½ gallon stock soda solution. Remove liquor.
2. First suds. Use 1 gallon stock soda solution and 2½ gallons stock soap solution. Run machine for 10-15 minutes, gradually raising temperature of liquor to 140°-160° F. Remove waste liquor.
3. Second suds. Introduce warm water into machine; also 1 gallon stock soda solution and 2½ gallons stock soap solution. Bring liquor to boil in 15 minutes and boil 10 minutes. Remove liquor.
4. Rinse in hot water for 5-6 minutes.
5. Rinse in fresh hot water for 3-4 minutes.
6. Rinse and blue in lukewarm water.

It is evident from a consideration of previous statements and the details given in the above examples, that the more or less complete removal of starch from heavily starched goods in the ordinary washing process is dependent chiefly upon the following factors:—

1. The peculiar properties of soap solutions, (*vide* p. 229)
2. The rubbing action of the articles upon each other.
3. Influence of heat.
4. Amount of starch present.
5. The length of time occupied in the process.
6. The presence or absence of "glazes."

The action of soap solution has been already discussed. It is well known that if insufficient soap be used in the machine, the dirt already extracted exhibits a tendency to settle out on the

goods. Friction is of the greatest service in loosening the starchy matter, while it is prevented from becoming excessive by the action of soap and alkali as fibre lubricants. Heat facilitates the action of the detergents, but excessive amounts of the latter are of little use in hastening the removal of starch, while apart from considerations of economy, they exert a degrading influence on the fibres.

The process becomes more complicated when "glazes" containing insoluble matter have been used in conjunction with starch for welding the surface-fibres together.

Obviously, a more rational system of washing than the foregoing, would be one in which the starch could first be converted into soluble derivatives so as to facilitate the subsequent detergent and penetrative action of the washing solutions employed. A method of removing starch from fibres based on this principle has long been used in certain textile trades, but it is only during the last few years that the practice has been successfully introduced into laundries, owing chiefly to the lack of inexpensive and suitable compounds capable of bringing about the desired result in a comparatively short period of time.

With the introduction of concentrated malt extract preparations for textile purposes, however, the washing problems, in so far as the removal of starch is concerned, have been very much simplified. The proper use of one of these preparations in the breakdown is of considerable advantage, because, apart from a slight reduction in the total time occupied, as compared with the usual washing process, a less drastic treatment is permissible, so that the "linen" undoubtedly lasts longer and its "colour" is better and more uniform.

Commercial malt preparations are sold under various proprietary names, and considerable care needs to be exercised in order to ensure that a reliable article is obtained. The extract is simply added to ordinary water, the solution thus obtained being used at temperatures between 105°-160° F. The most intensive action of these compounds occurs between 140°-160° F., but their action on starch ceases at temperatures above 168° F. They may be used either in the breakdown or in separate baths. In the latter case, the bath can be kept for a considerable time, fresh quantities of the malt preparation being added as occasion demands, until the liquor finally becomes too dirty to be further utilised. This mode of procedure is carried out by adding the requisite amount of the malt preparation to warm water contained in a suitable tank. The temperature of the water should be raised to about 120° F., and the goods—which have been previously

well rinsed in lukewarm water—steeped overnight while the bath cools down, or if preferred, for a comparatively short time during the day, while other goods are being washed. If this method is adopted the length of time of the subsequent wash may be shortened from about 10 to 15 minutes. In most laundries, however, in which malt extract is used, it is customary to carry out the treatment in the rotary machine. In this case, the least possible amount of water consistent with the proper manipulation of the goods should be used, and the machine run for a reasonable length of time—about 10-15 minutes—since successful results are chiefly dependent on (*a*), the liquefying and saccharifying powers of the malt enzymes; (obviously, the greater the volume of a solution containing a definite weight of malt-extract, the slower will be its action on starch); (*b*), the temperature employed, and (*c*), the time occupied in the treatment.

In order to prevent the coagulation and fixation of albuminous matter—usually present on the goods, as well as in malt preparations—it is inadvisable to exceed a temperature of 120° F., so that a longer period of treatment is desirable than at a temperature of (say) 140° F.

It is well known that the activity of malt enzymes ceases in presence of solutions of soap or alkali; hence if chemically softened water is employed, it is essential that any traces of alkali which may be present, should be neutralised by adding the requisite quantity of a suitable acid, preferably acetic, before adding the malt extract to the water.

Malt preparations are now used on a very large scale in the treatment of collars, cuffs, and shirts. They are of especial value for effecting the rapid removal of starch from soiled coloured goods, *e.g.*, printed shirts, cuffs, etc., with a minimum amount of friction, thus enabling the brightness and intensity of shade of each colour to be more fully preserved than appears to be possible in the ordinary process of washing. An example is given below:—

Example 3:—

1. Breakdown for 5 minutes in cold water.
2. Second breakdown for 5-15 minutes at about 120° F. with the addition of 4-6 ozs. of malt extract. Remove liquor.
3. First suds. Use cold water, and add 1 gallon stock soda solution and 2½ gallons stock soap solution. Run machine for 10-15 minutes. Raise temperature of liquor gradually to 140°-160° F. Remove waste liquor.
4. Second suds. Use warm water and soda as before. Also 2 gallons stock soap solution. Bring liquor to boil in 10-15 minutes and boil for the same length of time. Remove liquor.
5. Rinse in warm water for 5 minutes.
6. Second rinse in warm water.
7. Rinse and blue in cold or warm water.

The length of time of each of the various operations may be reduced or increased according to the condition of the goods. Reference has been made in a preceding paragraph to the use of a standing bath for the treatment of heavily starched goods with malt preparations, and it would appear as if this mode of procedure offered certain advantages—especially as regards efficiency and economy—when compared with the use of such substances in the breakdown. On the other hand, however, the practice gives rise to many complications in dealing with the work as it is received and entails additional labour, while unless great care is taken, it may induce the formation of mildew stains; hence steeping in tanks is not likely to meet with any great measure of success, at any rate in domestic steam laundries.

Example 4:—

This process includes a bleaching operation with sodium hypochlorite or other suitable "chlorine bleach."

1. As in No. 2 process.
2. Ditto.
3. Second suds. Introduce warm water into machine; also ¾ gallon stock soda solution, 2½ gallons stock soap solution, and ½-¾ pint of sodium hypochlorite 14° Tw. Bring liquor gradually to boil and boil for 10 minutes. Remove waste liquor.
4. Rinse in hot water for 5 minutes.
5. Rinse in fresh hot water containing 1 % of its weight of commercial acetic acid for 5 minutes.
6. Rinse in hot water for 5 minutes.
7. Rinse and blue in warm water.

Example 5:—

This includes a bleaching operation with sodium perborate.

1. Breakdown for 10 minutes using cold water. Remove dirty water.
2. Introduce fresh cold water into machine, and add 1 % (on weight of goods) of sodium perborate (containing 10 % available oxygen) and 2 % of curd soap previously dissolved. Bring to boil in 15 minutes and boil 20-30 minutes. Remove liquor.
3. Rinse in hot water for 10 minutes.
4. Warm rinse and blue.

A malt breakdown may be employed with advantage in each of the examples given above. In works in which the cold process of starching is employed, it is advantageous to give collars, cuffs, etc., a preliminary treatment with boiled starch in the washing machine as already described in a preceding paragraph. For this purpose about 1-1½ lbs. of maize or rice starch are boiled up with 3 gallons of water, and the pasty mass added to the last rinsing water. This method may be adopted in all the foregoing processes.

Table "Linen."—The impurities which have to be removed from table linen during the washing process are dirt, starch, greasy matter, and stains of different kinds. Only a small

amount of starch is usually present—indeed, in some cases it is not used in finishing table linen—and both the nature and amount of the other impurities vary to a considerable extent.

It is evident, therefore, that a washing process of much less stringency than the examples given above for the treatment of heavily starched goods will suffice for such articles as tablecloths, serviettes, etc.

The following are two typical examples:—

Example 1:—

1. First suds. Use ¼ gallon stock soda solution and ¼ gallon stock soap solution. Temperature of liquor 120° F. Run machine for 15 minutes. Remove waste liquor.
2. Second suds. Use cold water and add 1 gallon stock soda solution + 2 gallons stock soap solution. Raise gradually to boil and boil 15 minutes. Remove liquor.
3. Rinse in hot water for 5-6 minutes.
4. Rinse in warm water; blue, and starch, using 1½ lbs. maize or rice starch in 3 gallons of boiling water.

If the goods are not white enough they may be subjected to a bleaching operation with sodium perborate, sodium hypochlorite, bleaching powder solution, or one of the proprietary "chlorine bleaches" on the market. If one of the latter is used, the operation may take place either during the boil or the first hot rinse, or immediately after the latter, but the greatest care should be taken to ensure the complete removal of all traces of soap when using a "bleach" containing a salt or salts of a metal capable of decomposing soap, *e.g.*, bleaching powder solution. The operation may also be conducted in the cold, using a slightly stronger solution or working for a longer period, and should be followed by thorough rinsing, first in warm and then in cold water. A souring operation, *i.e.*, treatment with weak acid is advantageous and usually follows the first rinse after bleaching, a final rinse completing the process. The use of sodium hypochlorite in the washing process commonly employed for table "linen," is shown in the following example:—

Example 2:—

1. Breakdown in cold water for 5 minutes. Remove water.
2. Alkaline breakdown. Use ¾ gallon stock soda solution. Raise to 120° F. in 10 minutes. Remove liquor.
3. Wash. Use warm water and add 3 gallons stock soap solution + ½ gallon stock soda solution + ½-¾ pint of sodium hypochlorite 14° Tw. Raise to boil and boil 15 minutes. Remove waste liquor.
4. Rinse in hot water for 6 minutes.
5. Blue and starch. Use 1½ lbs. of starch previously boiled in a few gallons of water.

Body "Linen."—The various articles comprising body "linen" and practically all articles with tapes are commonly washed in open net-work bags, in order to prevent entanglement during the rotation of the cylinder. With a similar object in

view all attached strings, *e.g.*, apron strings, etc., are carefully tied before the goods are introduced into the machine. In addition to dirt, body "linen" is usually contaminated with perspiration, which, being of an albuminous nature, is best removed by a preliminary treatment with an alkaline detergent at a medium temperature. Yellow perspiration stains are commonly met with, and the most satisfactory method of effecting their removal appears to be a treatment with sodium perborate in the wash. In other respects the washing processes are similar to those already described.

Example:—

1. Breakdown for 10 minutes at 100° F., using ½ gallon stock soda solution. Remove waste liquor.
2. First suds. Run machine for 20-25 minutes. Raise temperature to 140°-160° F. Use 1½ gallons stock soda solution and 1½ gallons stock soap solution. Remove liquor.
3. Second suds. Use 1 gallon stock soda solution and 2½ gallons stock soap solution. Raise to boil and boil 15-20 minutes. Remove waste liquor.
4. Rinse in hot water for 5-6 minutes.
5. Rinse in warm water and blue.

A little boiled starch may be added in last rinse if desired. If colour of goods is unsatisfactory, add ½-1% of sodium perborate to contents of machine in second wash.

Handkerchiefs, Muslins, etc.—These are frequently contaminated with stains and a considerable amount of dirt of a variable nature, so that it is customary to subject them to a fairly energetic treatment. Practically all the processes advocated for heavily starched goods are suitable, the length of time occupied in each operation being increased or shortened according to the condition and nature of the goods.

Example:—

1. Breakdown for 5-10 minutes in the cold using ½ gallon stock soda solution. Remove liquor.
2. First suds. Use ¾ gallon stock soda solution and 1 gallon stock soap solution. Run machine for 15-20 minutes, raising liquor to 140°-160° F. Remove waste liquor.
3. Second suds. Use stock soda solution as before and 1½ gallons stock soap solution. Raise to boil and boil 10 minutes. Bleach if necessary. Remove waste liquor.

4-6. Three rinses; blue in last rinse.

Household Dusters, Dirty Towels, etc.—These are generally contaminated with a greater amount of dirt and greasy matter than the classes of goods dealt with in the preceding paragraphs; consequently a more energetic treatment is desirable, and larger amounts of soda can be used with advantage. As starch is not usually present, a treatment with malt extract is, of course, of no advantage.

Example I—

1. Breakdown for 5-10 minutes in the cold using 1-1½ gallons stock soda solution. Remove liquor.
2. First suds. Use 1 gallon stock soda solution + 1½ gallons stock soap solution. Run machine for 10 minutes. Temperature as in previous examples. Remove waste liquor.
3. Second suds. Use warm water and add soda as before + 2 gallons stock soap solution. Run machine for 15-20 minutes under same conditions as in second suds. Remove liquor.
4. Third suds. Use warm water and add 1 gallon stock soda solution + 2 gallons stock soap solution. Also add "bleach" if necessary. Raise to boil and boil 10 minutes. Remove waste liquor.
5. Rinse in hot water for 5-7 minutes.
6. Rinse in warm water for 5 minutes.

Sheets, Pillow-Slips, Chamber Towels, etc.—These are washed in the same way as table "linen," preference being given to the first process, unless the colour is unsatisfactory, in which case the second process should be employed, or the goods subjected to a separate bleaching operation.

White and Cream Curtains.—Lace curtains are washed either in the machine or by hand. The latter method is usually adopted when the curtains have become weak by long exposure to the sun, or when only a small trade is done in such goods. It is the general practice when washing curtains in rotary machines to enclose them in open net-work bags to prevent entanglement and also to lessen the strain on the lace. New curtains of inferior quality often contain mineral impurities such as china clay, etc., which are added to the size pastes used in sizing the threads. Goods of this nature require careful handling. Formerly, the first operation in washing curtains in machines consisted of a breakdown in a weak solution of sodium carbonate, but now that the launderer has a choice of numerous "starch solvents," it is more rational to steep the goods, first of all, in water containing a small quantity of a malt preparation, and to wash subsequently according to one or other of the methods given below.

Example 1 :—

1. Steep overnight in warm water containing from ½-1 lb. of a suitable malt preparation in every 20 gallons.
2. Breakdown for 5 minutes in lukewarm water + 1 gallon of stock soda solution. Remove liquor.
3. First suds. Use stock soda solution as before and 2-3 gallons stock soap solution. Raise temperature of liquor to about 150° F. in 15 minutes. Remove waste liquor.
4. Second suds. Introduce warm water into machine; add ¾ gallon soda solution and soap as before; also ½-1 pint sodium hypochlorite 14° Tw. Raise liquor to boiling point and boil for 10 minutes. Remove liquor.
5. Rinse in hot water for 5 minutes.
6. Rinse in warm water for 5 minutes.
7. Blue and rinse in cold water.

The above process may be employed for new curtains containing size and mineral matter, and for goods which have not become too weak by long exposure to sun and air.

Example 2:—

1. Breakdown in warm water for 5 minutes.
2. Breakdown for 10 minutes, using 4-6 ozs. malt preparation. Temperature about 120° F. Remove liquor.
3. First suds. Use cold water; add 1 gallon stock soda solution and 2 gallons stock soap solution. Run machine for 15 minutes gradually raising temperature of liquor to 140°-160° F. Remove waste liquor.
4. Second suds. Use warm water, and add soda and soap as before. Raise to boil and boil 10 minutes. Remove liquor.
5. Rinse in hot water for 5 minutes.
6. Bleach with 1-1¼ pints sodium hypochlorite, or bleaching powder solution 14° Tw., in lukewarm water.
7. Rinse in hot water for 5 minutes and sour with acetic acid.
8. Rinse in cold water and blue.

In the foregoing example, the goods are in the machine for a longer time than in the first process, the difference being due to the malt breakdown, the bleaching operation, and the final rinses. Like the first example, it is best adapted for comparatively strong goods. Weak curtains and those of an expensive nature are usually washed by hand.

In hand washing, the curtains are immersed in a solution of a neutral oil soap contained in a wooden or earthenware vessel, and gently rubbed by the operator from time to time. Finally they are rinsed and blued in another vessel. The "soaping" is repeated with fresh soap if one treatment does not yield satisfactory results. Cream curtains are treated in the same manner as white curtains, but they are subsequently tinted either with a coal-tar dye or with "nitrate of iron." If the latter is employed, the goods are immersed in a weak solution for a short time, squeezed, and then passed into a dilute solution of sodium carbonate, whereby an iron buff shade of greater or less intensity,—according to the strength of the "nitrate of iron" bath and the length of time of treatment,—is developed and fixed on the fibre.

Coloured Cotton and Linen Goods.—The articles included under the above heading are printed shirts, cuffs, handkerchiefs, furniture covers, curtains, etc.; and also similar articles in which the colour effects have been produced by using dyed threads in the weaving process. Goods of this nature must be treated with great care, as many of the colours are not fast to alkaline solutions, although the majority usually withstand a warm solution of an oil soap. If starch has been used in finishing, the first part of the washing process should consist of a steeping operation for a short time in a weak solution of malt extract at a temperature of about 90° F

Coloured cotton and linen goods are not often washed in the rotary machine unless it has been found that the colours are not appreciably affected by the solutions used. The usual practice is to employ ordinary round wooden vessels. In the absence of starch, the goods are first agitated by hand in lukewarm water and then in a warm solution of an oil soap. If the articles are very dirty, a second treatment in a fresh soap solution will be necessary; badly soiled parts should be brushed with soap solution on a suitable board. Finally, the articles are rinsed in warm water and then in dilute acetic acid, after which they are hydro-extracted and dried.

In dealing with parti-coloured goods of any description, it is of vital importance not to allow them to lie about in the wet state, or the colours will "run" or "bleed" into the white parts of the materials. Many colours which are extremely fast to washing, are, nevertheless, subject to "bleeding" under these conditions.

SECTION V.—WASHING.

WOOLLEN AND SILK GOODS.

In the preceding pages we have given a detailed description of the various washing processes used only for articles made of cotton and linen. The mode of cleansing woollen and silk goods will now be described.

All articles made of wool and hair have to be handled very carefully in the laundry, in order to avoid, as much as possible, the felting or shrinking which readily takes place under suitable conditions. The usual explanation of the cause of felting has already been given in the chapter dealing with textile fibres, and it is well known that this property possessed by wool and allied fibres, is influenced to a great extent by friction at a high temperature, especially in presence of alkaline or acid solutions. Consequently, it is essential that the temperature of the liquors used in washing should be carefully regulated; too much friction must be avoided, and the wash liquors should consist of solutions of slightly alkaline oil soaps that readily penetrate the fibres, and do not gelatinize quickly on cooling.

Felting does not take place so readily with fine wools as with the coarser varieties, but in laundry practice, the mode of washing is not often altered to suit the kind of wool from which the different articles have been made, so that much depends upon the skill of the operators.

The better qualities of woollen goods are still washed by hand in most laundries, vessels of wood or earthenware being employed for the purpose. The former are usually made by cutting 40-gallon oil casks to the requisite size. Heavy goods and many articles of wear are commonly washed in the ordinary rotary machines, but in well equipped laundries, specially designed machines termed "flannel washers" are used. One of the best known of these is the *Williamson Flannel Washing Machine*, which is shown in Figs. 102 and 103, the latter being a sectional end view. It consists essentially of a wooden trough in which a "press" or "hammer" swings backwards and forwards when actuated by the driving gear. The trough and other parts of the machine are supported by means of iron standards of a convenient working height. A pair of squeezing rollers is placed

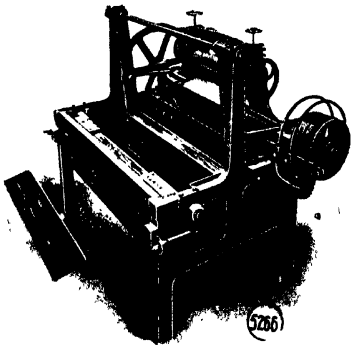


FIG. 102.—WILLIAMSON'S FLANNEL WASHER.
(Manlove, Alliott and Co., Ltd.).

in a suitable position for taking the flannels as they are withdrawn from the machine. Two patterns of this type of machine are built, one of which is fitted with one set of gearing for driving both the machine and squeezing rollers, while two sets of driving pulleys are furnished with the other pattern. The illustration shows the former pattern. In working the machine, the flannels are placed circular fashion (not lengthways) between the press A and the spring boards B, both of which are corrugated. When in use, the press works backwards and forwards, squeezing the goods against the spring boards, which yield slightly to the pressure, being connected by means of the crank arms C to the india-rubber springs D. This mode of action causes the flannels to be rolled over and over, thus continually presenting a fresh surface

to the action of the press and boards, while the soap liquor is forced into intimate contact with all parts of the goods.

Another form of flannel washing machine is illustrated by Fig. 104, while Fig. 105 represents an American type of machine The former consists of a wooden trough divided into three compartments. Above these are fixed two rope covered squeezing rollers, the lower one being driven very slowly by belt gear, while the upper one revolves by contact. The mode of working is as

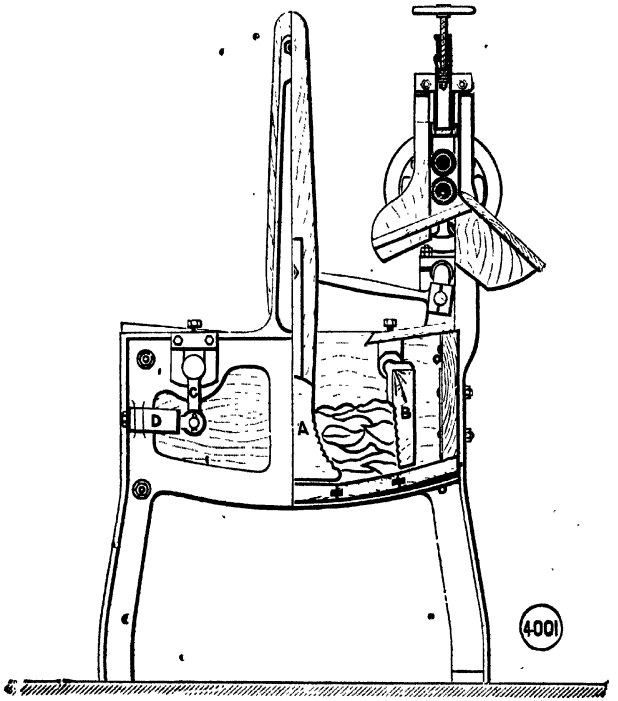


FIG. 103.—WILLIAMSON'S FLANNEL WASHER. END SECTION.

(Manlove, Alliott and Co., Ltd.)

follows:—The woollen goods are placed in soap solution in one of the end troughs and are picked out by hand from time to time and passed between the squeezing rollers back into the trough. When they have been cleansed sufficiently, they are passed to the next compartment, in order to remove excess of soap. Finally, they are rinsed and squeezed in the third compartment. A carrier

and safety devices are fitted in front of the rollers, so that the hands of the operator do not come near the latter.

The American type of flannel washer is designed on similar lines to the ordinary rotary washer. The outer vessel is V shaped and open at the top, while the cylinder into which the goods are introduced is divided lengthwise into several compartments. In this arrangement the articles are continually rolled over and over without being subjected to a high drop. A comparatively

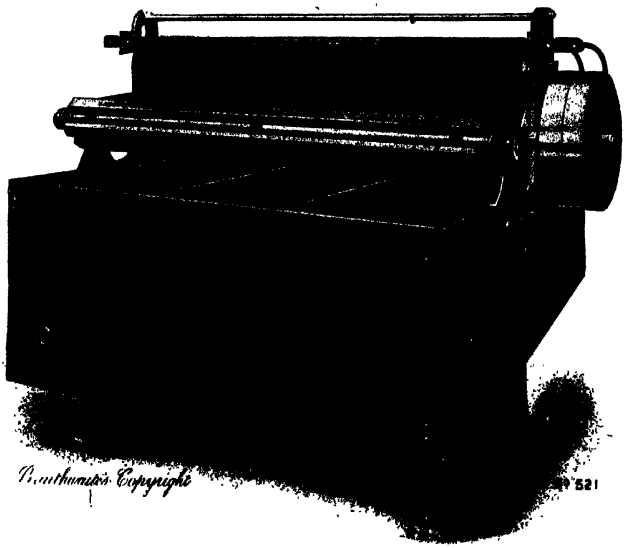


FIG 104 'IBIS" FLANNEL WASHER
(I. Braithwaite and Son, Ltd.)

small volume of water is required, thus enabling the amount of soap used to be reduced to a minimum. The machine is also serviceable for washing lace curtains and other delicate goods, or for dealing with a large number of small lots of goods which need to be kept separate. Nets are not required. A flannel washer of modern design is shown in Fig. 106. It differs entirely from the foregoing machines, both in the mode of construction and the principle upon which it works. A stationary outer metal case, almost oval in section, is mounted on suitable supports. In the

interior of this case is a cage of somewhat similar form built of brass rods and suspended in bearings near the top. When the machine is in use, the cage swings backwards and forwards, and at each swing one side practically dips into the washing liquor,

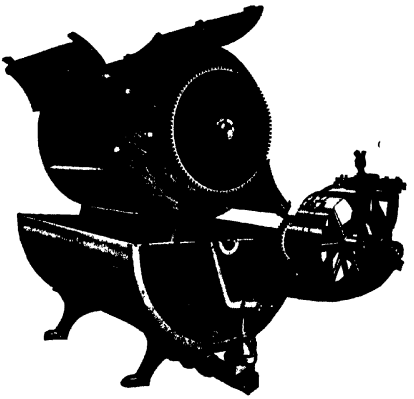


FIG. 105.—"TROY" FLANNEL WASHER.
(J. Armstrong and Co., Ltd.).

which lies at the bottom of the outer vessel. Hence, at each oscillation, the liquor rushes over the goods contained in the cage and then percolates through them into the outer case to undergo subsequently the same cycle of movements.

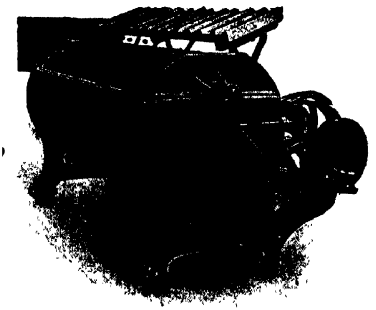


FIG. 106.—"WATERLEAP" FLANNEL WASHER
(R. G. Whitaker, Ltd.).

At one end of the machine is fixed a tank for holding soap solution, which can be run into the machine and mixed with suffi-

cient cold water as occasion demands. It is stated that comparatively clean woollen goods can be washed in from 5-8 minutes, and dirty woollens in from 8-12 minutes. The machine may also be used for washing goods containing colour effects, as well as other articles which need a gentle and comparatively short treatment.

The classification of woollen goods varies to a considerable extent in different laundries, but the following example is typical of modern practice:—

1. Fine Articles of all descriptions.
2. Ordinary white goods.
3. Grey flannels.
4. Coloured articles.
5. Stockings and socks.

Fine Woollen Goods.—All fine goods are washed by hand. They should be sorted into white, cream, and coloured articles, and washed in this order, so that the soap liquor used for the white and cream articles also serves for the coloured goods. The temperature of the soap solution should not exceed 90° F.

Surface dirt is first removed by steeping in water. The goods are then introduced into the soap liquor and squeezed gently by hand until they are clean. Dirt which cannot readily be removed in the soap bath, must be brushed with soap solution by hand, the articles being placed on a suitable table or board during the operation. A second soap liquor is used if the goods are not clean enough. They are next rinsed in water at a temperature of 90° F., and subsequently given a second rinse in water at the same temperature containing a small quantity of oil soap. Finally they are wrung, shaken out, and dried at about 100° F. Fancy articles containing colour effects may be washed as above, but cold soap solutions must be employed if the colours exhibit a tendency to bleed.

White and coloured silk goods are washed in the same way, but exceptional care must be taken in the treatment of weighted silk articles, especially when contaminated with perspiration stains. Indeed, it is much safer to employ a dry cleaning process for goods of this description.

Ordinary White Goods.—Flannels, blankets, cricket trousers, etc., are usually washed in machines, either the rotary or one of the flannel washing machines being employed. It is found in practice that a good type of the latter class gives the best results, since the goods do not felt so readily as when machines of the former type are used.

When the ordinary form of rotary machine is employed it is very important that the inner cage should revolve slowly and reverse after about 1-1½ revolutions. In actual practice, the goods are not allowed to remain in the machine for more than about 10-15 minutes. Some goods, however, require a longer treatment than others, especially if they are contaminated with perspiration stains, but in all cases excessive friction must be guarded against, or felting will inevitably occur.

Ammonia is frequently added to the soap liquor; it undoubtedly assists in the removal of albuminous and greasy matter.

The salient characteristics of all washing processes for woollen goods have been already mentioned in our description of the treatment which fine articles undergo. When machines are employed, the first operation consists of a rinse for a few minutes in cold or tepid water to remove surface dirt and acid substances For comparatively clean goods, (*e.g.*, blankets), this operation is usually omitted. The articles are next washed in a solution of an oil soap with or without the addition of a little ammonia or potassium carbonate, the length of time occupied being dependent upon the condition of the goods. About 10 minutes is the average, the operation being repeated if the articles are not clean enough. They are then removed from the machine, excess of soap liquor expelled by squeezing, and the goods introduced into a vessel containing water at 90° F. They are finally given a rinse in a weak solution of an oil soap, passed as flat as possible between the rubber rollers of a wringer, shaken out, and dried. For large articles the hydro-extractor may be used, but the cage should rotate only at a medium rate.

Blankets are frequently rinsed in a series of wooden tanks between each pair of which is fitted a pair of squeezing rollers. This method of rinsing is very useful in public institutions and in works in which a large trade is done in the cleaning of heavy woollen articles.

When only small quantities of comparatively clean articles have to be washed, the whole of the operations may be carried on in the same machine without removing the goods, but in this case, the soap liquor employed is not easily available for washing dirty goods, unless, of course, means are provided for transferring it from the machine to a suitable vessel from which it can be reintroduced into the washing machines.

Grey Flannels.—These are washed in the soap liquor which has been already used for white goods. In other respects, our remarks on the treatment of the latter apply also to the washing of grey flannels. "Jaegar" articles are usually washed by hand.

Stockings and Socks.—If soap liquor which has been previously used for washing other goods be used for stockings and socks, it should be passed before use through a piece of cloth in order to remove the loose fibres and fluff which are usually present.

A solution of American cotton seed oil soap with the addition of a little potassium carbonate may be used for common and dirty articles. A second wash with oil soap is then given, each operation occupying about 10 minutes or less according to the condition of the goods, the temperature being 90° F. The articles are finally well rinsed in clean water at 90° F., squeezed and dried. One washing operation for about 10 minutes in a solution of oil soap is generally sufficient for the majority of goods of better quality.

Coloured Goods.—These are washed according to the general instructions for other goods, the articles being sorted according to colour. If it is found that some colours are not very fast to washing, cold soap solutions must be employed and the washing and wringing operations should be completed as quickly as possible. Coloured articles are often rinsed in a weak solution of acetic or sulphuric acid for the purpose of brightening the colours. After the acid bath, they are rinsed again in water, wrung, shaken out, and dried.

SECTION VI.—WOOL AND SILK BLEACHING.

White woollen and silk goods gradually assume a yellowish tint during wear, and this is not appreciably affected by the ordinary washing process. It has been pointed out, that, in the case of cotton and linen goods, the yellowish tint exhibited by these fibres may be "neutralised" by a blueing operation, but in the case of woollen goods, such a treatment is of little use, in so far as it enhances the purity of the white. The colour of silk goods, however, is considerably improved if the articles are rinsed after washing in a very weak solution of a basic violet such as one of the brands of methyl violet. Yellowish woollen goods are usually whitened by a bleaching process with hydrogen peroxide, which oxidises the yellow pigment of the fibre to a colourless compound, in this way producing a permanent white. Formerly, woollen goods were bleached in the laundry by suspending them whilst moist in a closed chamber containing sulphur dioxide gas. The white obtained by this method reverts to the original colour of the fibre after the goods have been exposed to the air for some time, a change which is facilitated by the use of the usual alkaline washing solutions. Owing to the fact that the process is com-

paratively cheap, however, many of the fabrics from which articles of wear are made, are still bleached in this way by the manufacturers.

When hydrogen peroxide is used for bleaching purposes, it is generally made by dissolving sodium peroxide in cold water previously acidulated with sulphuric acid. Acid is necessary in order to neutralise the caustic soda produced by the action of the peroxide on water, as:—

$$Na_2O_2 + 2H_2O = 2NaOH + H_2O_2.$$
$$2NaOH + H_2SO_4 = Na_2SO_4 + 2H_2O.$$

In making up a bath for bleaching purposes, the peroxide is added gradually to cold water, to which the necessary quantity of sulphuric acid has been previously added. The liquid is con-

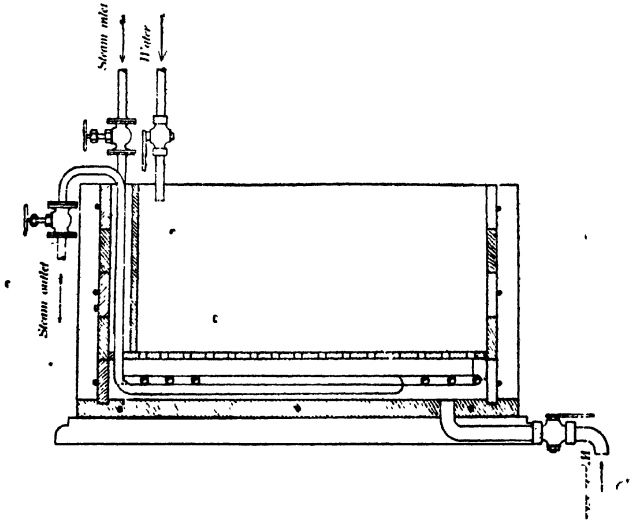


Fig 107.—Bleach Vat for Woollens. Section.

tinually stirred during the addition of the peroxide, and its temperature should be kept at about 35° C., in order to prevent loss of oxygen. After the whole of the sodium peroxide has been added, the liquid is tested with litmus paper and rendered neutral by the addition of more sodium peroxide or sulphuric acid according to its reaction. Finally it is made slightly alkaline by the addition of a small quantity of ammonia. Various substances have been recommended as additions to the bath prepared in

the above way, chiefly with the object of rendering the bleaching liquor more stable, thus ensuring the liberation of oxygen with greater regularity and at a comparatively slow rate. Among these may be mentioned silicate of soda, ammonia, and ammonium phosphate.

The following proportions of ingredients are usually recommended for the preparation of a neutral bleach liquor suitable for the finest qualities of wool and silk goods:—

Water 100 gallons.
Sodium peroxide 7¾ lbs.
Sulphuric acid 8 lbs.
Sodium phosphate 3 lbs.

The liquor should be made, and the actual operation conducted, in wooden, earthenware, or slate vessels, since most metals, with the exception of lead, cause a rapid evolution of oxygen. A suitable apparatus is shown in Fig. 107.

The vessel is of white wood put together in such a way that no nails or bolts can come into contact with the liquor. A closed

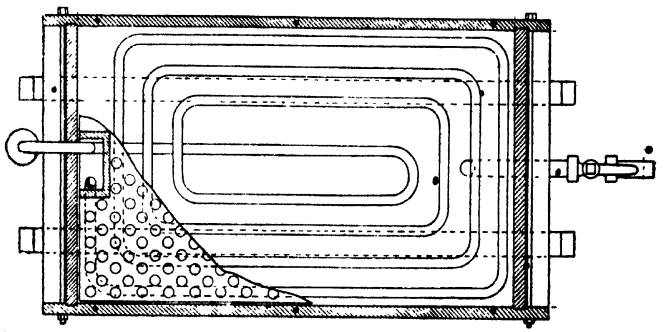


FIG. 108.—BLEACH VAT FOR WOOLLENS. PLAN.

steam pipe of lead, arranged in coils (Fig. 108), is placed at the bottom of the vessel, and above this is a false bottom built up of shaped pieces of wood, which are placed in position as shown in the diagram. This arrangement prevents the goods from coming into direct contact with the steam pipe and allows solid impurities to settle on the main bottom of the tank. A movable cover of wood (not shown in diagram), either perforated or made of laths, is usually fitted just beneath the surface of the liquor, in order to keep the goods completely submerged during the bleaching operation.

The articles to be bleached are first worked in the usual manner, then squeezed and immersed in the bleaching liquor, the temperature of which is raised to about 120° F. The goods are pushed beneath the surface of the liquor and allowed to remain therein overnight. They are then thoroughly rinsed, squeezed, and dried. A weak acetic acid solution may be used for rinsing followed by a second rinse in clean water.

SECTION VII.—HYDRO-EXTRACTING OR WRINGING AND "SHAKING OUT."

The operations dealt with in this section immediately follow the washing process. The object of hydro-extracting, or wringing, is to remove excess of water, the particular method adopted being dependent upon the nature of the goods. Fine cotton, linen, and silk articles, and many classes of woollen goods are

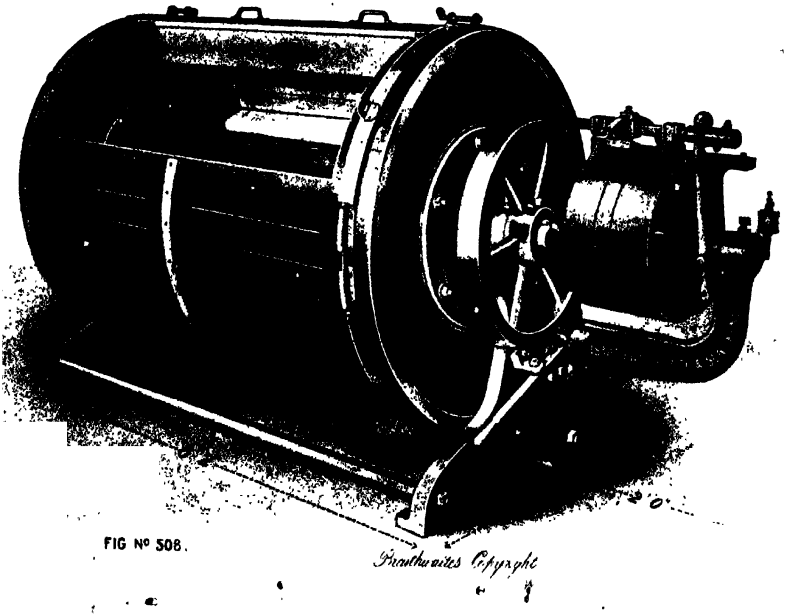


FIG. 109.—"IBIS" TUMBLER.
(*I. Braithwaite and Son, Ltd.*).

passed between the rubber rollers of a wringer under medium pressure, but in most cases, the hydro-extractor is employed. In

many works, the goods are introduced directly into a "tumbler" after their removal from the hydro-extractor. This machine is similar in construction to an ordinary rotary washer; it is used to separate or "shake out" the individual articles, while at the same time loose fibres, *i.e.*, lint, are removed. Formerly, "shaking-out" was done by hand, but by the use of a tumbler the work is done better and in a much shorter time. The constructional details and mode of working of the usual form of tumbler will be readily understood by a glance at Fig. 109. A description of a combined tumbler and drying room is given in the chapter dealing with the practice of drying.

SECTION VIII.—DRYING.

After washing, and hydro-extracting or wringing, a great many articles have to be dried. Goods which have been slightly starched in the washing machine, *e.g.*, table "linen," are dried on the machines during the process of finishing, while similar goods generally known as "flat work" containing no starch, are now commonly dried and finished in one operation by means of the multiple ironing machines. Articles which need to be highly finished, *e.g.*, collars, cuffs, etc., are not dried after washing. In most other cases, drying immediately follows the removal of excess of water, and a brief account of modern practice as well as the underlying principles will now be given.

Principles of Drying.—The practice of drying textile articles by natural means, *i.e.*, by exposure out of doors, is not now a feature of modern laundry work, owing to its uncertainty as regards time and degree. Artificial systems of drying differ only from natural processes in that they are designed to hasten the drying operation with a minimum expenditure of heat; their employment entails many precautions, however, since they are attended with certain disadvantages which can only be overcome by a careful study of the nature of the material to be dried, and the conditions which militate against, as well as those which favour the regular production of satisfactory results.

All drying processes, whether natural or artificial, depend upon the fact that wherever there is water, evaporation takes place, *i.e.*, the water rises into and mingles with the atmosphere in the form of vapour, producing a separate atmosphere of aqueous vapour, which is not influenced by the presence or absence of ordinary air, except as regards the speed at which evaporation takes place. The lower the pressure of the atmosphere, the greater is the speed of evaporation, while the greater

the pressure, the less is the speed. For any given temperature a certain space can only occupy a definite quantity of vapour and the air in the space is then said to be saturated with aqueous vapour at that temperature. The higher the temperature, the greater is the amount of vapour in saturated air. At the point of saturation the pressure of the vapour prevents further evaporation, so that if the space in a drying room becomes saturated with aqueous vapour at a certain temperature it is evident that further drying cannot take place until the density of the vapour is decreased, or the temperature raised. Under natural conditions the saturation point is rarely reached, for the aqueous vapour diffuses into the surrounding atmosphere just like other gases, the rate of diffusion being dependent on the vapour pressure, which latter is governed by the temperature. The higher the temperature, the greater is the pressure exerted by the vapour; hence the greater is the speed of diffusion.

The degree of saturation of air with aqueous vapour, or its humidity, is usually expressed in per cent. of the total amount it can hold at a given temperature, *i.e.*, the humidity of a definite volume of saturated air at any given temperature is 100, whereas when the same volume contains only half as much vapour as it can hold under the same conditions its degree of humidity is 50. If the temperature of saturated air be lowered ever so little, moisture is deposited, and the temperature at which this occurs is known as the dew-point; hence, the temperature of saturated air coincides with the dew-point. The influence of temperature on the amount of moisture which can be held by a definite volume of air is shown graphically in the following diagram (Fig. 110), for the use of which we are indebted to the Sturtevant Engineering Company, Ltd. The ten curves correspond to the percentage of humidity from 10 to 100, and, as mentioned above, the dew-point at any given temperature is that at which the relative humidity is 100 per cent. Reference to the table shows that a cubic foot of air at 60° F., reaches its saturation point when it contains about 6 grains of moisture, whereas when it is heated to 140° F., it is capable of taking up 50 grains before reaching saturation point.

The degree of humidity of air is measured by an instrument known as a hygrometer, of which there are several forms. The best known type consists of two thermometers, one of which registers the ordinary temperature, while the bulb of the other is kept moist by means of a piece of wet muslin. Hence, in the latter case the evaporation of moisture takes away heat from the bulb and thus a lower temperature is registered than in the case of the dry bulb instrument. If the air is dry, evaporation takes place more

readily, thus causing the wet bulb thermometer to register a greater fall in temperature, and by noting the two temperatures and reference to specially-compiled tables, the degree of humidity is indicated.

Another type of hygrometer which appears to be very useful, has been introduced under the name of Hygrodeik. It consists essentially of a wet and dry bulb thermometer attached to a scale which enables the degree of humidity to be read off directly, thus dispensing with tables.

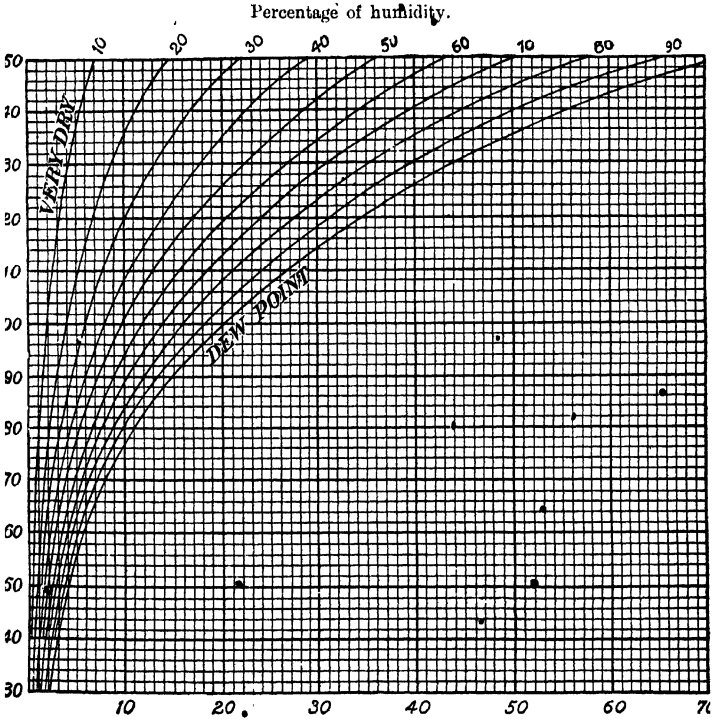


FIG. 110.—HYGROMETRIC CHART.

It will be evident from the foregoing remarks, that a system of drying which depends upon the conversion of water into vapour and its subsequent removal in that form is influenced to a greater

or less extent by (*a*), the temperature, (*b*), the rate of diffusion and (*c*), the amount of surface exposed.

Reference has already been made to the fact that drying ceases if the air becomes saturated with aqueous vapour, and it then becomes necessary to raise the temperature or to remove the saturated air. In all systems of drying, the latter method is adopted either by natural or artificial means. It follows, therefore, that the degree of efficiency of natural and artificial drying processes is primarily dependent upon, (*a*) the facility with which the excess of water in the material to be dried can be converted into vapour, and (*b*) the speed with which air containing a greater or less amount of water vapour can be replaced by fresh air. Now if the material to be dried is warmed, the water it contains is more or less rapidly converted into vapour, and this may be removed in various ways. In designing any system of drying, therefore, we have to determine (1), how best to warm the material and (2), what method to adopt for removing the saturated air. In many textile processes it is the custom to dry the goods by bringing them into contact with heated metal surfaces, but this method is best adapted for drying long pieces of single-ply cloth in a comparatively short time. It possesses many disadvantages, and is liable to degrade the physical properties of the fibres concerned unless proper precautions are taken.

The drying systems now generally used are dependent upon the use of air as the medium for applying the heat to the material to be dried, as well as for removing the water vapour. Thus, it is important that the properties of this medium upon which its use depends, should be briefly discussed.

The Atmosphere.—Ordinary air consists of a mixture of about 21 vols. of oxygen and 79 vols. of nitrogen, a greater or less amount of water vapour, and small amounts of other gases, as well as minute quantities of impurities derived from various sources. Air is regarded as a non-conductor of heat, but it absorbs heat readily, each unit absorbed raising its temperature much higher than water. In common with other gases it diffuses more readily as its temperature rises, so that it conveys heat to other substances with great readiness. Owing to its elastic properties, air exerts no deleterious action on the finest fabric, while its fluidity enables it to be easily moved in large volumes with a comparatively small expenditure of power and with little friction. The pressure of the atmosphere varies with the altitude; at the sea-level it is equal to about 15 lbs. per square inch, which is known as one atmosphere, but it decreases as the altitude increases. This pressure retards the immediate conversion

of liquids into vapour, and when the vapour pressure of a liquid just balances the atmospheric pressure, the temperature at which this occurs is called the boiling-point of the liquid.

When subjected to the action of heat, air expands; hence it becomes more attenuated. On cooling contraction takes place. Therefore, if hot air is caused to come into contact with a cold surface such as a damp cloth, it parts with heat and at the same time contracts, thus possessing a tendency to leave the material along with more or less of the water which has been vaporised. Compared with aqueous vapour it is to be noted, that as the temperature of ordinary air rises, its weight decreases, whereas in the case of the former an increase in temperature causes its density to become greater. Thus at 0° C., a cubic foot of vapour weighs about 0.000304 lb., whereas at 100° C., it weighs 0.03682 lb. irrespective of atmospheric pressure. On the other hand, a cubic foot of air at 0° C., weighs 0.0807 lb., and at 100° C., 0.0591 lb.

It is obvious, therefore, that the greater density of air compared with that of water vapour under all working conditions is of the highest importance in enabling the latter to be readily moved, for, owing to its highly attenuated nature even at medium temperatures, it is difficult to conceive of a ready means of handling it with economy, if it were necessary to deal with it separately instead of when mixed with air.

A consideration of the above statements serves to show that air constitutes an ideal medium for the conveyance of heat to the articles to be dried as well as for the removal of vapourised water.

The Practice of Drying.—The conditions under which the drying of detached articles is effected in the laundry are principally dependent upon the nature of the articles and the kind of treatment to which they have been already subjected. Broadly speaking, goods made from vegetable fibres can be dried at a higher temperature than those made from fibres of animal origin without suffering any appreciable injury. Articles heavily impregnated with boiled starch need to be dried as rapidly as possible, and it is considered by some authorities that the high temperature which is requisite in order to accomplish this result, exerts a degrading influence on the "colour" of the goods as well as upon their tensile strength.

Woollen goods are usually dried at a temperature of about 120° F., as it is well known that rapid drying by exposure to hot air or dry heat induces shrinkage and harshness, while white articles have a tendency to become yellow. The chief systems of dry-

ing which are in use at the present time have been already described in the chapter devoted to machinery, and it is unnecessary to enter into any further details here.

An interesting process of recent introduction, however, differs from the usual practice, in that the goods are "shaken out" and dried in one and the same machine, immediately after removal from the hydro-extractor. The machine employed for the purpose is known as a dry-room tumbler, a front view of which is illustrated in Fig. 111A, while Fig. 111B represents a sectional view, showing air discharge, steam coils, forced draught fan, and tumbler compartment. It consists of a woven brass or galvanized iron wire cylinder, which is fastened to a suitable iron framework. In the interior of the cylinder are four wooden "lifters," each of which is about $3\frac{1}{2}$ inches high. These "lift" the goods to the

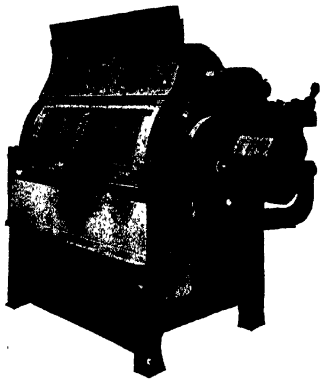


Fig. 111A.—Dry Room Tumbler.

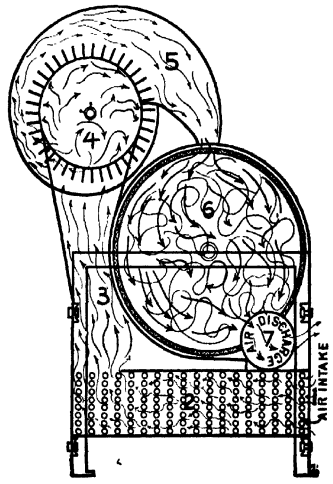


Fig. 111B.—Dry Room Tumbler. End Section.

(J. Armstrong and Co., Ltd.).

top of the cylinder during its rotation and then allow them to drop by gravity, thus keeping them open to a greater or less extent so as to ensure rapid and uniform drying. The driving and automatic reversing gear is situated at one end of the machine, and causes the cylinder to make three revolutions alternately in each direction.

Immediately beneath the cylinder is a series of steam coils, 2, over which a current of air is drawn by means of an exhaust

fan, 4. The coils are made in two sections, and are arranged in such a way as to radiate more or less heat as required. They are supported by means of iron rollers resting on an iron track, so that any one of the coils can be easily removed for cleaning and examination.

The exhaust fan is placed at the back of the machine and is driven by a shaft on which are fitted fast and loose pulleys; this arrangement enables the machine to be used as an ordinary tumbler. The outer casing is of galvanized iron, the cylinder and steam coils being separated by an iron baffle plate, thus ensuring that all air entering the machine must first pass over the coils and then through the cylinder, 6; finally it passes into the atmosphere at the discharge outlet shown in the diagram. Hinged doors are provided for both inner cylinder and outer casing. The machine is adapted for the rapid drying of such articles as towels, underwear, bathing suits and shirts, overalls, aprons, carpets, etc., etc. The air is said to acquire a temperature of 250° F., and is sent through the machine at the rate of 5,000 cubic feet per minute. The continuous shaking of the goods in the strong current of heated air, imparts a "finish" to flannels, etc., which is, of course, unobtainable by the ordinary drying process, and in many cases no further finishing is required.

SECTION IX.—FINISHING.

The term "finishing" is used in this work to indicate the whole of the operations which the various classes of goods undergo after they have been cleansed, and—if necessary—dried. Woollen and silk goods are finished in a comparatively simple manner, but the finishing of those articles which must possess a full and stiff handle, as well as a greater or less amount of lustre and pliability, necessitates the exercise of considerable skill and judgment in order that satisfactory and uniform results may be obtained.

Cotton and Linen Goods.—Practically all laundry finishing processes for cotton and linen articles may be divided into two main branches, viz.:—1. Starching, and 2. Ironing. Each of these may be further sub-divided into several operations which are subject to considerable variation according to the nature of the articles to be treated, the kind of "finish" required, the nature of the machinery, and the kind of starch employed, *i.e.*, whether raw or boiled starch. As the goods to be finished consist of small detached articles of various shapes and thicknesses, it is evident that the methods of conducting the operations, must of necessity be entirely different from those which obtain in the finishing of

piece-goods, although in both cases, the underlying principles are essentially the same. Many effects produced in finishing certain articles, *e.g.*, collars and cuffs, are undesirable in the case of piece-goods.

1.—STARCHING.

As its name implies, starching is an operation which has for its object the impregnation of the fibres of the goods with a mixture composed principally of starch. This result may be attained in several ways and by using starch in the raw form suspended in cold water or after boiling with water.

One method of starching certain classes of goods in conjunction with the washing process has been described in a preceding paragraph, but for such articles as collars, cuffs, fronts, and parts of shirts, it is inadmissible, owing to the large amount of water present as well as on account of the unsuitability of the ordinary washing machine for heavy starching. Consequently, all articles which need to be highly stiffened, have to undergo a special starching operation which is usually carried on in one of the numerous power machines commonly known as "starchers." This is the operation to which the term "starching" as used in the laundering trade generally applies.

Modern starching processes for goods which need to be highly stiffened are distinguished by names which are dependent upon the nature of the starch mixture employed. Thus there is the raw or cold starch process; the boiled starch process, and the "double starch" process. The first named—if not the oldest—is certainly the best known, and is used in the majority of British laundries in which domestic articles are re-dressed. In new work laundries, either a mixture of boiled or raw starch, *i.e.*, "double starch," or boiled starch alone is in general use, while in the United States the latter appears to be almost exclusively employed both for old and new goods.

The boiled starch process is only employed to a limited extent in Great Britain and Ireland. Its adoption necessitates the employment of special appliances and great care is required in the manipulation of the goods, both during and after the starching operation. On the other hand, the process is said to be quick and enables the goods to be finished in a comparatively short time. With regard to the latter statements, however, it is to be noted, that, although the actual starching operation is completed in the course of a few seconds, nevertheless, the subsequent operations to which the goods are subjected before they are ready for ironing, take up a considerable amount of time. The use of boiled starch

for the treatment of large quantities of collars, cuffs, etc., has undoubtedly several points in its favour when pliability is of greater importance than a full, thick, and stiff feel, and when the finished goods have not to be stored for any length of time, but in other respects the process does not appear to possess any pronounced advantage in comparison with ordinary British practice. As stated above, raw starch is principally employed for the production of stiff work in the domestic laundries of this country, and an account of its mode of application will now be given, while the *modus operandi* in connection with the boiled and "double starch" processes will be described in the chapter dealing with the treatment of new goods.

The Raw Starch Process.—The operations involved in starching with raw starch may be classified as follows:—

1. Preparation of the starch mixture.
2. The starching operation.
3. Hydro-extracting or wringing.
4. "Wiping-down."

1. *Preparation of the Raw Starch Mixture.*—A stock supply of a mixture of starch in a solution of borax and water is first prepared by adding the starch with constant stirring to the borax solution. The volume of water used should only be sufficient to thoroughly soak the starch, so that a homogeneous pasty mass is obtained from which the starch does not settle out on standing. After being prepared in this way, the mixture is placed in suitable vessels and kept well covered.

The mixture for use in the starching machines is prepared by taking a convenient quantity of the stock paste and diluting to the necessary strength with water, the "strength" being determined by means of Twaddell's hydrometer. The average amount of borax employed, is about 1½-3 ozs. for every 1 lb. of starch; on no account should it exceed 3½ ozs., since an excessive quantity induces friction during the ironing process, with the result that the fibres are weakened, lack pliability, and have a tendency to crack. Very little investigative work has been done in connection with the action of borax on starch; it is maintained by some authorities that it is used chiefly to soften the water employed in the starch mixture owing to the injurious action of lime salts upon starch. It appears to be highly probable, however, that in addition to its action as a water softener, borax possesses the power of modifying starch in a way that has not yet been discovered, for it is well known, that the use of a mixture of starch and borax in starching, gives results in finishing, which are unobtainable by the use of starch alone even when soft water is

employed. A small quantity of one of the numerous "glazes" on the market is usually added to the stock starch paste or it may be added to the mixture used in the actutal starching operation as required. It should be, of course, a "glaze" readily miscible with starch and water, and free from a tendency to settle out rapidly. The amount employed depends upon the effect required and is usually given by the maker, although it is best determined by practice. Glycerine is also commonly added to the starch, about $\frac{1}{8}$ oz. to $\frac{1}{4}$ oz. for each lb. of starch being ample. These additions are made chiefly with the objects of assisting in the production of gloss and imparting pliability to the finished articles, while they also assist in preventing the goods from sticking to the surfaces of the ironing machines in the subsequent processes.

If a "glossy" finish is required without having recourse to the use of a "glaze" of unknown composition, a little Japan wax, say about 2-4 ozs., should be boiled with 1-1½ lbs. of starch and sufficient water, until a homogeneous paste is obtained. This is allowed to cool, and then thoroughly mixed with about 15 lb. of raw starch (previously made into a smooth mass with cold water). The whole is finally diluted to 8° Tw. for use.

2. *The Starching Operation.*—The "strength" at which the starch mixture is used for collars, cuffs, etc.—as indicated by the hydrometer—depends primarily upon the kind of finished effect required, the mode of removing the surplus starch after the starching operation, the nature of the starch employed, and the amount of water in the goods to be treated. As a rule, the mixture is used at from 6°-8° Tw. The higher the strength, the greater is the degree of contamination of the surfaces of the goods with "surface starch," which has to be removed previous to ironing, in order to obtain uniform results. In testing with the hydrometer, care should be taken first to stir the mixture thoroughly.

The machines in general use for heavy starching with raw starch, are known as dip-wheel and barrel "starchers," several types of which are described on pages 152-155. In this mode of starching, the goods are subjected to an energetic tossing and rubbing, thus facilitating the entry of the minute granules of starch into the fibres, and, although a considerable amount of friction is induced, it is generally admitted that no other method gives such satisfactory results.

The collars and cuffs to be starched are hydro-extracted or wrung immediately after their removal from the washing machine, and then introduced into the "starcher," which should only be filled to about half its capacity. The starch mixture is then added in sufficient quantity as determined by practice, and the machine

closed and set in motion. The operation is complete in from about 15-25 minutes.

3. *Hydro-extracting or Wringing.*—When the starching machine has been run for the necessary length of time, the goods are removed, and hydro-extracted or wrung in order to remove excess of water and starch. The former method is commonly employed, but unless conducted with great care, it is liable to give rise to faulty work. Running the machine at a high speed, or too long, should be avoided, since under such conditions, too much starch is removed, while a considerable amount may be left on the surfaces of the articles. Furthermore, it is well known that there is greater danger of the goods being stained than when the wringing method is adopted, although defects of this nature are more or less completely prevented by the use of cages made of white metal or aluminium.

4. "*Wiping-Down.*"—This operation immediately follows the removal of excess of starch and water. Its objects are to remove "surface starch," *i.e.*, surplus starch remaining on the surface of the goods, and to straighten out the articles in such a way, that most of the creases are removed, thus rendering them fairly smooth. The operator lays each article flat on a suitable bench, and then brushes it on both sides with a small brush, or wipes off the starch with a piece of clean cotton or linen, which is moistened from time to time, with a weak solution of borax.

When the starch mixture is not too strong, it is a good plan to straighten out the goods immediately after the starching operation, arranging them in batches of three or four articles of the same kind. The batches are next passed between the rubber rollers of a wringer under medium pressure, then straightened out again, if necessary, and passed through a second wringer. At this stage, they are ready for blocking on the press machine, and, if the foregoing operations have been properly conducted, careful "wiping down" is unnecessary. In most cases, however, the latter operation is essential—especially in the absence of a press plant—no matter what method has been previously adopted for removing excess of starch and water.

If the wringer is employed for the latter purpose, care should be taken that the pressure on the rollers is not too high, since there is considerable danger of excess of starch being forced into those parts of the articles which are the last to pass between the rollers.

When a hydro-extractor is used, it is best to reserve it for starched goods only. Machines specially designed for such work are now available. They are smaller than the usual type of extractor

met with, but, with the exception of removable outer cases,—usually made of copper, tinned on the inside,—they are similar in constructional details to those already described. When the outer case is removed, every part of the cage is easily accessible for cleaning.

Many attempts have been made to shorten the time requisite for efficient starching with raw starch in the dip-wheel and barrel "starchers," by the introduction of modified processes and specially designed mechanical appliances. None of the latter appears to offer any advantage, however, compared with the first named machines, although an interesting modification of the usual practice which has long been in use in Germany is described below.

Raw Starching with Hoffman's Machine.—The washed and hydro-extracted articles are first dried on "horses" in the usual way, and then starched in a dip-wheel starcher for six minutes, using the starch at 2½°-3° Tw. They are next straightened out and passed through Hoffman's continuous starching machine, the chief features of which, are a tank or starch-container and an endless travelling apron. The goods are placed upon this apron at one end of the machine and delivered at the other end after passing through a raw starch mixture and between squeezing rollers. The starch mixture advocated by the makers for use with the machine, consists of 1 lb. of rice starch, 2 ozs. borax, and 1 gallon of water; it is kept constantly stirred when the machine is in use by means of a mechanical agitator. After passing between the squeezing rollers, the goods drop into a basket, and are subsequently hydro-extracted and sent to the ironers. The above process can be facilitated as follows (private communication from D. Ross):—

First, hydro-extract thoroughly; omit the drying operations, use a starch mixture in dip-wheel machine at 4°-4½° Tw., running for six minutes as before; pass through Hoffman's machine after straightening out, as above, and iron on steam press. In this method one operator feeds the goods into the continuous starcher, while another collects and arranges the goods in flat heaps ready for the press.

There is still another modification of the raw starch process in use in a few high-class laundries, especially for the production of a stiff and high-grade "finish." It differs from the processes previously described in that the articles are first agitated in a comparatively weak boiled starch paste and then dried. They are next starched with raw starch in the dip-wheel starcher and finished in the usual way. It appears to be very doubtful whether this modified process offers any pronounced advantages compared with the ordinary process.

Attached shirt fronts and cuffs may be starched with a similar mixture to that first mentioned for collars and cuffs, at about 7° Tw., using the machine illustrated on page 156.

Shirts are dried after washing, *i.e.*, before the main starching operation, the bodies and sleeves as well as the other parts retaining a little of the boiled starch used in the final stage of the washing process. Hence, during the starching of the fronts and cuffs with raw starch, the bodies and sleeves of the shirts absorb moisture by capillary action, so that in many cases a preliminary damping of these parts before ironing is unnecessary. Uniform dampening of the bodies and sleeves is further assured by rolling up the goods and allowing them to lie for a short time immediately after starching. They are then ready to be ironed. The time occupied in starching shirt fronts or cuffs with the aid of the machine referred to above is about 3-5 minutes.

Starching Miscellaneous Articles.—Instead of using the washing machine for starching the various articles to which reference has been made in the chapter devoted to washing processes, a separate hand starching process in troughs may be adopted. This method offers little advantage over the former, except in so far as it enables a small saving in starch to be effected; it should be adopted, however, whenever it is necessary to starch expensive or delicate articles, such as lace curtains, which have been washed in bags, as well as for special articles which need to be stiffened to a greater extent than the majority of goods starched in the washing machine.

The apparatus employed for hand starching is comparatively simple; it usually consists of a wooden trough at one end of which is fixed a pair of rubber squeezing rollers. If much starching is to be done in the trough, it is customary to provide a small steam pipe for heating up the starch as required. For most goods starched by hand, maize or farina starch is used, but in the case of articles which have to be in use for a considerable time before re-washing and re-dressing, it is advisable to use a mixture of one of these with rice starch, since it is well known that goods finished with a mixture of this kind do not exhibit such a pronounced tendency to become limp on exposure to air for some time as is the case with goods finished with the first-named starches. This phenomenon is due to the greater hygroscopic nature of maize starch and farina as compared with rice starch. The use of the latter alone yields results which are too hard. One of the commercial combined starches specially adapted for such work, or mixtures containing gum tragasol, may also be used with advantage.

For the commoner articles, farina is largely employed. The starch is added to the water with constant stirring and the mixture then boiled until a smooth homogeneous paste is obtained. The amount employed per gallon of water depends principally upon the degree of stiffness desired, and can be easily ascertained by practice. A suitable amount of one of the proprietary "glazes" may be added to the boiled starch paste.

2.—IRONING.

The last process in the finishing of cotton and linen articles is known in the laundry as ironing. It may be either simple or comparatively difficult, according to the nature of the treatment to which the goods have been previously subjected. The objects achieved during the ironing of the various articles may be enumerated as follows:—

1. Excess of water is removed from the goods in the form of steam.
2. The granules of raw starch burst in presence of the steam generated in the fibres, *i.e.*, the starch is gelatinised.
3. The fibres of the goods are caused to cohere by means of the adhesive starch, thus forming a compact mass of fibres and starch.
4. The surfaces of the articles are rendered flat and uniform, so that lustre or gloss is produced by the reflection of a greater or less amount of light according to the degree of flatness and uniformity attained.
5. The goods are shaped according to requirements.

Collar, Cuff, Front, and Shirt Ironing.—The most important of all ironing processes is in connection with the finishing of collars, cuffs, and other heavily starched goods. For articles which have been starched with raw starch, *e.g.*, collars, the process includes the following operations:—

1. Blocking and steaming.
2. Polishing or glossing.
3. Edge ironing and shaping.

After the goods have been starched and hydro-extracted or wrung, they are "prepared" for the blocking operation by first subjecting them to an operation technically known as "wiping" or "wiping-down," which—as already mentioned—is carried on by an operator who arranges the collars, etc., on a suitable board, straightens them out with a piece of blunt wood or bone, and

rubs any surface starch into the fibres by means of a canvas rag, or a little brush, which is frequently moistened with a weak solution of borax.

1. *Blocking and Steaming.*—After "wiping-down," the goods are ready for blocking. Its object is to "set" the starch on the articles, *i.e.*, to develop its inherent adhesive and stiffening properties so that the fibres become bound together in such a way as to render the surfaces of the goods more or less uniform and flat; a considerable amount of moisture is removed during the operation in the form of steam, hence the term "steaming." Blocking is now done on a large scale with the aid of the steam press, but many other methods find extensive application, and it is evident that the mode of procedure actually adopted is dependent upon the kind of plant installed. The following list includes most of the methods which obtain in practice:—

Methods of Ironing Collars, Cuffs, etc.

1. Block and polish on table machines.
2. Block on table machine; polish on roller machine.
3. Block on steam press; polish on table machine.
4. Block on steam press; polish on roller machine.
5. Block on steam press, and polish with hand irons.

An account of the construction and mode of using each of the above machines is given in the section dealing with ironing machinery. Immediately after blocking, the goods are ready for glossing, but before this can be accomplished satisfactorily, excess of water has to be removed; hence, it is chiefly on this account that most goods have to be passed several times between the rollers of ordinary glossing machines. The first passages are essentially drying operations, and when the goods are just damp enough a polish is rapidly developed.

2. *Polishing.*—The final operation of the ironing process, viz.:—Polishing or glossing, is also carried on in different ways (see above). Its object is to impart a lustrous or glossy appearance to the goods, this being achieved by subjecting them while damp to friction at a fairly high temperature. The friction is set up by the upper and lower surfaces of the machine parts moving at different rates of speed, and at the same time exerting considerable pressure upon the goods while the latter pass between them. As a general rule only the right sides of heavily starched goods are polished. In some works it is the custom to smear the surfaces of various articles with a small quantity of "glaze" by means of a canvas rag during the final polishing operation. This is done in order to obtain a high gloss and in some cases to impart a better appearance to inferior goods.

The application of "glaze" can also be effected by means of the machine shown in Fig. 112. This apparatus has been specially designed for the purpose of enabling a slight film of moisture or "glaze," as the case may be, to be applied in a perfectly uniform manner to collars and cuffs, and is termed a "surface dampener and glaze applying machine." Attached to a suitable framework is a geared rubber-covered roller which is capable of revolving with the lower part in a circular trough filled with the liquid to be applied. Around this roller is wound a layer of calico, or thin flannel if a pasty "glaze" is used. This covering is stripped of superfluous liquid as it emerges from the tank by means of a small geared vulcanised roll, while a similar roll presses the right sides of the goods against the moistened covering of the main

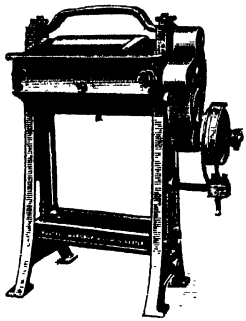


FIG. 112.—SURFACE DAMPENER AND GLAZE APPLYING MACHINE.

(*Russell, Wardrop and Co.*).

roller as the articles pass through the machine. Pressure on the rollers is obtained by a lever and weight and remains constant when once correctly adjusted.

3. *Edge Ironing and Shaping.*—As soon as the ironing process is judged to be complete, those articles which require shaping are passed through one of the machines described on pages 215-6. Double collars are turned down before shaping, but previous to turning-down, the seams are dampened in order to prevent the "linen" from cracking. Rough edges are dampened and ironed smooth on one of the various edge ironers.

For turning and ironing the points of wing collars and for ironing the tabs of double collars special appliances have been introduced. Fig. 113 illustrates the "*Troy*" *Wing Point Tipper*. It consists of an iron framework supporting a steam heated metal chest on the underside of which is a polished circular shaped open-

ing. Immediately beneath this is a metal cone covered with suitable elastic material, and supported by means of a rod running in guides and attached to a foot treadle. Above the heated chest is a flattened tube which communicates with a condenser and the latter with the steam supply, thus ensuring that only dry steam passes out at the exit. Collars to be treated are first shaped, and then the wings dampened by means of the ascending steam from the flattened tube. A collar is next placed in proper position on the cone, and, by depressing the treadle, caused to come into contact—under considerable pressure—with the steam heated chest.

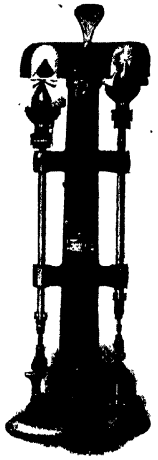


FIG. 113.—"TROY" WING POINT TIPPER.
(J. Armstrong and Co., Ltd.).

Thus, the wings are turned down and ironed. The illustration (Fig. 113) shows a double cone machine which enables the operator, working from side to side, to place one collar in position while another is being tipped.

The *Tab Tipper* has been designed for ironing the tab ends of double collars in order that any portion exposed to view when the tie is in place will present an appearance comparable to the "finish" on the face of the collar. Like the points of wing collars, these tab ends are on the reverse side of the collar as it passes through the ironing machines but are exposed to view when the collar is worn. It is obvious, therefore, that the appearance which they exhibit is different to that exhibited by the face of the collar. Tab tippers usually work on the press principle. The chief feature of one form of apparatus is a flat steam heated head or chest,

against which a pair of rubber and felt covered flat jaws can be pressed by means of an automatic locking and releasing treadle. No dampening is required, two tabs being placed in position with their right sides against the heated head and pressure applied.

Ironing by Hand.—In all modern laundries ironing by hand is still carried on to a considerable extent. Indeed, this mode of finishing certain classes of goods is essential in order to get the best results. Such articles as blouses, pillow and cushion covers, frilled goods, certain classes of collars, etc., which cannot be readily manipulated on machines, are commonly ironed by hand. New embroidered bed spreads, pillow shams, handkerchiefs, etc., etc., are also usually ironed in like manner. In some cases the ordinary flat or sad irons are used, but when a suitable supply of gas is available, it is the universal practice to employ internal

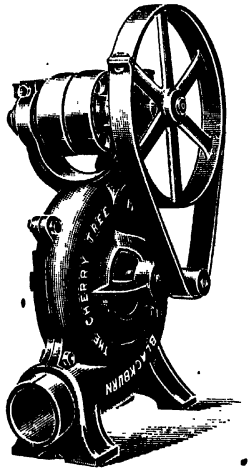


FIG. 114.—AIR "BLOWER."
(Cherry Tree Machine Co., Ltd.).

combustion gas irons. The usual type of this kind of iron is of the same general appearance as an ordinary household box iron, but it is provided with an atmospheric gas burner which points towards the bottom in the interior of the iron, so that the flame is directed downwards when the iron is in use. The upper part and sides are generally lined with asbestos or some other non-conducting and non-inflammable material in order to prevent loss of heat by radiation and to render the iron easier to manipulate. A mixture of gas and compressed air is led to the burner by

means of a flexible metallic tube, one end of which is screwed into the end of a projecting piece of metal tube which communicates with the burner, and the other end to the gas and compressed air supply pipes. Air under slight pressure is essential in order to ensure complete combustion of the gas and to maintain easily the requisite degree of temperature. It is usually supplied with the aid of a " blower " or centrifugal fan (Fig. 114), which is actuated by means of a countershaft and communicates with a distributing pipe supported above the ironing tables on suitable iron standards.

In order to avoid defective combustion caused by fluctuations in the pressure of the gas or air, the meter through which the former is supplied should be fitted with a reliable governor, and the " blower " should be driven independently, preferably by means of a motor.

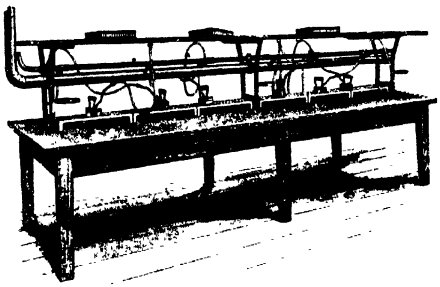


Fig. 115.—Arrangement of Gas Irons and Connections.

Regulating valves are fitted to the main gas and air pipes and when the proper mixture of air and gas has been obtained, a valve situated near the burner or supply pipes is regulated so as to produce the degree of heat required. Thorough mixing of air and gas is ensured by means of a so-called " mixing chamber " which forms part of the burner. The iron is placed on a metal stand when not in use, *e.g.*, while the operator is arranging the goods in position.

Fig. 115 shows an arrangement of gas irons and connections for a double ironing table with the standards down the centre.

Gas irons are made in different sizes and vary in weight from about 3 to 10 lbs. for ordinary work, the average weight being about 6 lbs.

For ironing articles with large plain surfaces, an iron of the form shown in Fig. 116 is commonly used. It weighs about 35-40

lbs. and may be heated according to the system described above, or by gas under pressure (see below). In the latter case a special burner is necessary. When not in use, the iron is pushed on to an inclined support.

The gaseous products of combustion formed in the interior of the iron, pass into the atmosphere through small openings usually placed near the top. They consist essentially of water vapour and carbon dioxide and are readily removed from the vicinity of the ironing table, provided that the room is efficiently ventilated. The use of irons which emit fumes of any description is prohibited by the Factory Acts. Hence it is evident that an ideal gas iron is one which is totally enclosed, with inlet and outlet tubes for the mixture of gas and air, and products of combustion respectively. An arrangement of this kind introduced by Eaves has long been in use and is highly satisfactory, although the initial

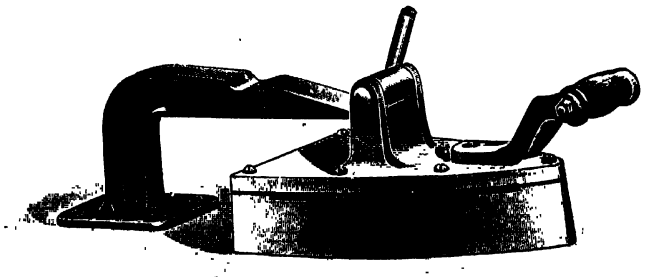


FIG. 116.—"QUEEN" GAS IRON.
(Cherry Tree Machine Co., Ltd.).

cost and subsequent wear and tear are greater than in the case of the ordinary arrangement. In Eaves' system the pipe through which the products of combustion pass into the outside atmosphere should be of copper, since iron is very readily attacked.

Electric irons have been on the market for many years, but they do not appear to have been adopted to any great extent. They are cleaner than gas irons, and, as the heating is effected by passing a current of electricity through a special type of resistance, noxious fumes are entirely prevented. Unfortunately, however, it is generally admitted that a high temperature cannot be maintained with economy, when using these irons, and their use appears to be chiefly confined to the ironing of certain classes of goods in dry cleaning establishments.

"Pressure Gas Irons."—During the last few years considerable attention has been paid to the perfecting of gas irons into which

gas only is introduced under pressure, sufficient air being drawn in from the atmosphere by suction through suitable openings to ensure complete combustion when the mixture is burnt. It is obvious that a heating system of this kind for hand irons or machines possesses several advantages when compared with those described above. Only one main supply pipe is required, and the mixture of gas and air can be easily regulated. The flexible tube connecting the main gas pipe and iron need only be of small diameter; consequently, the tube is not so much in the way as a thicker and heavier tube and the whole system is characterised by simplicity

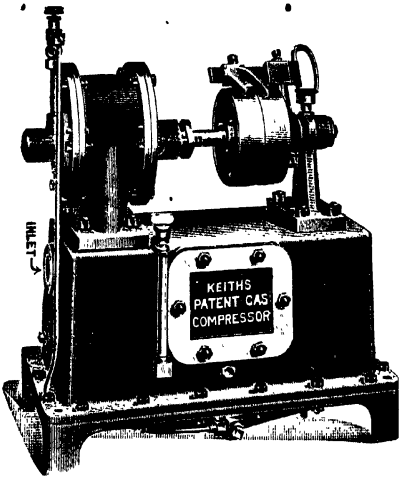


FIG. 117.—GAS COMPRESSOR.
(J. Keith and Blackman Co., Ltd.).

of arrangement. A typical plant working on this principle is described below. It includes a gas compressor, distributing pipe, and "pressure gas iron." The compressor (Fig. 117), consists of a positive rotary blower mounted on a box containing two compartments, one for the gas supplied and the other for the compressed gas. The former is connected to the gas supply pipe and the latter to the distributing pipe from which the irons are supplied. Communication is established between the two compartments by means of a pressure regulating valve, which can be set to any pressure with the aid of disc weights. The usual pressure of the gas as supplied to the irons is equal to 54 in. water column. The "blower" may be driven by belt, water, or electric motor, and lubrication is effected automatically.

The "pressure iron", is shown in Fig. 118. It is not unlike the ordinary type of gas iron in general appearance, but the tube leading into the iron is fitted with an adjustable perforated device for allowing the necessary volume of air to be drawn into the interior by the force of the issuing jet of gas. When the proper mixture of gas and air has been ascertained, the air adjustment valve is locked into position, so that interference with the arrangement by the operator is impossible, thus the chief cause of defective heating is eliminated. By means of a special form of bye-pass the supply of gas can be easily regulated. When it is in one position the gas is full on; in another position only sufficient gas is allowed to pass to keep the iron warm, while in the third position it is shut off altogether. Thus, the temperature of the iron can be regulated to suit the goods under treatment, and the simplicity of the mode of control renders it possible to effect a considerable saving of gas.

The irons are made in three standard sizes, viz. :—8, 10, and 12 lbs.

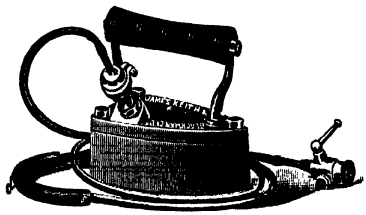


FIG. 118.—"PRESSURE IRON."
(*J. Keith and Blackman Co., Ltd.*).

Fig. 119 shows Summerscales' compressor, with flexible tubing, gas iron, and gas control valve. It is coupled to the ordinary gas supply pipe on the left (see figure), while the compressed gas issuing on the right hand side passes into the distributing main from which it is supplied to the irons. The compressor is self-regulating, thus adjusting itself to the quantity of gas passing through the pipe.

The compressed gas system of heating irons and other appliances appears to be displacing the older system in up-to-date laundries. Very little space is taken up by the compressor; it may be fixed on the ironing table or floor, but the best arrangement is to attach it to brackets overhead. The compressed gas can also be utilised for illuminating purposes.

Hand ironing is usually done on strongly built double tables with the gas or gas and air supply pipes passing down the centre.

The tops of the tables are covered with a good thickness of felt and on this is placed a covering of cotton cloth.

Shirt Ironing.—The fronts and cuffs of these may be blocked and polished on table machines in one continuous operation, using a shirt board, to which the front of the shirt is attached; or the cuffs may be ironed on one machine, and the fronts or bosoms on a bosom ironer. The yoke is subsequently ironed on a yoke ironer and the body and sleeves ironed by hand. Finally the collar band is ironed on a band ironing machine, using a neck band ring, or it may be finished by hand.

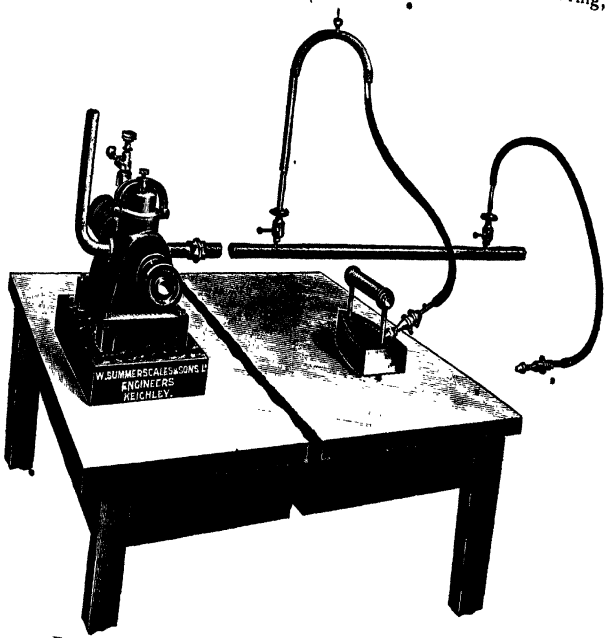


FIG. 119.—GAS COMPRESSOR, GAS IRON, VALVES, AND CONNECTIONS.
(*W. Summerscales and Sons, Ltd.*)

The shirt board described on page 190 is useful for ironing négligé shirt fronts with buttons sewn on; if this or a board of similar type is not available, they are ironed by hand.

In small laundries the ironing of shirts is done entirely by hand, while in many of the high-class establishments in which

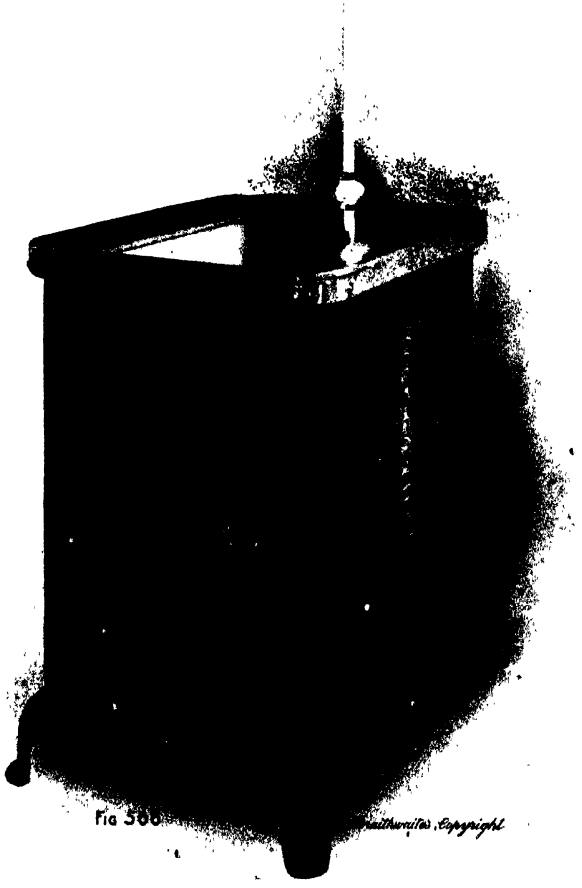


FIG. 120.—VAPOUR DAMPENER.
(*I. Braithwaite and Son, Ltd.*).

a large number is dealt with daily, the heavily starched parts and the yoke are ironed with the aid of steam press machines, the

bodies being finished by hand. The "finish" obtained in this way is perfectly smooth and appears to be highly satisfactory, although it does not exhibit much gloss.

Ironing Miscellaneous Articles.—A detailed account of the methods of ironing each of the numerous articles sent to the laundry is scarcely possible in a work of this nature, and in any case it is doubtful whether such a description would serve a useful purpose. Consequently, we give below an outline of the usual mode of procedure in dealing with each of the miscellaneous classes of articles enumerated. All goods which have been impregnated with boiled starch need dampening before they can be ironed, *i.e.*, if they have been dried after starching. Under ordinary circumstances, however, many articles which have been lightly starched with boiled starch during the washing process and subsequently hydro-extracted may be ironed directly without drying. In this case, those goods, *e.g.*, flat work, which are passed through the decoudun require at least two passages in order to ensure satisfactory results.

If dampening be necessary, various methods are available. Sprinkling with water by means of a can provided with a fine rose is a common practice, the articles being subsequently rolled up and allowed to lie for some time. In large laundries, so-called mist or vapour dampeners are often employed, one of which is illustrated in Fig. 120.

On a low stand is a tank of galvanized iron open at the top and enamelled both inside and out. A wire screen arrangement or holder for the goods to be dampened is fitted in the interior, the lower end being about one inch from the bottom of the tank in order to prevent the garments from dipping into any water or dirt which may accumulate therein. At the bottom is an outlet for draining purposes.

The water used for damping the goods is atomized, *i.e.*, converted into a mist or vapour by causing it to pass first through a steam injector and finally through fine orifices in special brass nozzles. A strainer is fixed between the latter and the injector, so as to retain any particles of dirt which would otherwise clog up the nozzles.

An air blast is sometimes used instead of an injector for atomizing the water, but the use of the latter conduces to more rapid and efficient work, inasmuch as the water is heated in its passage, with the obvious result that the mist produced, possesses more rapid penetrative power than a mist produced with the aid of cold water. The apparatus illustrated is arranged for water pressure only, of not less than 12-15 lbs. per square inch.

Special appliances known as dampening presses are frequently employed in conjunction with dampeners, for the purpose of equalising the dampness of the goods. A typical dampening press is shown in Fig. 121. Pressure is obtained by means of steam or hydraulic power and is applied or removed by merely turning a valve.

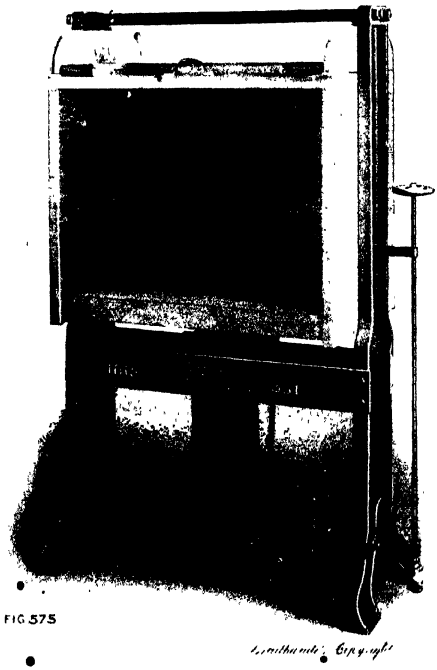


FIG. 121.—DAMPENING PRESS.
(*I. Braithwaite and Son, Ltd.*).

Skirts and parts of blouses are usually ironed on skirt boards covered with felt. One of these is shown in Fig. 122. It merely consists of a tapering padded board mounted on a suitable support. A smaller board—commonly known as a sleeve ironing board—is usually fitted underneath; it is very serviceable for ironing the sleeves of various articles. The use of these appliances enables the articles to be drawn round and round as the ironing proceeds.

Frills on pillow cases, pinafores, cushion covers, curtains, and other articles are finished by goffering, using irons with different sized prongs, so as to produce fine or coarse work according to the nature of the goods. The other parts of such articles are either ironed by hand or on body ironers, which latter are also commonly employed for underwear, and miscellaneous goods of a more or less plain description.

An ordinary hand goffering iron is shaped like a pair of scissors, but is provided with two round prongs, usually made of steel. In some cases irons with three prongs are used, one prong fitting in between the other two; hence, more flutes can be made at one operation than with the double-pronged iron. Machines are now

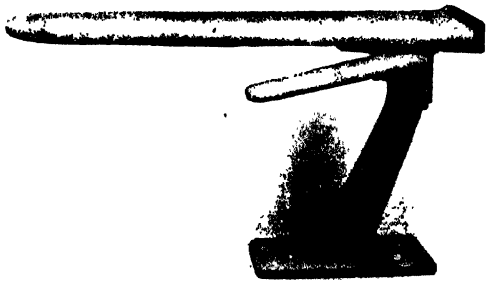


Fig. 122.—Shirt and Sleeve Ironing Boards.
(*Manlove, Alliott and Co., Ltd.*).

largely used for goffering ordinary goods. In general construction they resemble the two roller sleeve ironer, but the rollers are fluted and gear into each other. The lower roller is usually smaller than the upper one and is raised and lowered by means of a treadle and connections. In one type, the machine is simply clamped to a table and driven by a handle, pressure being obtained by means of a spring, while the hollow rollers are heated by introducing red-hot heaters. Fig. 123 shows a machine mounted on a cast iron stand and provided with fast and loose pulleys for power. The treadle is fastened to the foot of the stand and when depressed causes the rollers to gear into each other, at the same time actuating mechanism which sets the machine in motion. The large roller of power machines is heated by gas, and the pressure between it and the smaller one can be easily regulated. The flutes of the rollers are of different sizes and shapes, and, as the rollers are interchangeable, fine, large, or medium flutes of different shapes

can be readily obtained. The material used in the construction of the rollers is brass.

Steam bolts of various sizes (Fig. 124), are very useful for ironing parts of articles which are difficult to iron in the usual way without flattening, *e.g.*, sleeves of blouses, etc. They consist of hollow steam heated drums generally made of copper in different sizes and shapes. In use, the part of the article to be ironed is placed upon the bolt and stretched by hand until it is shaped properly and the desired finish obtained. Embroidered articles should always be finished on the wrong side, so as to preserve the raised effect of the embroidery, the latter being in contact with the felt of the ironing board or machine during the operation.

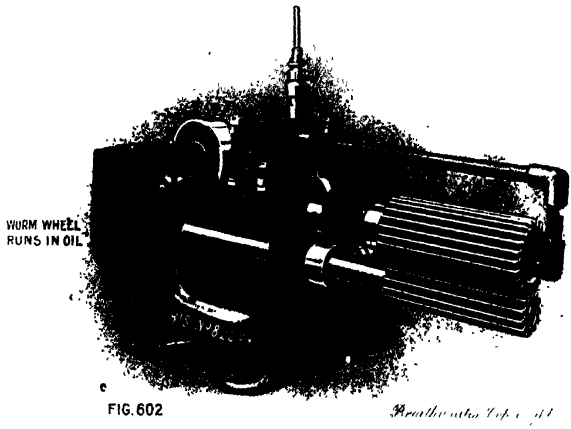


FIG. 123.—GOFFERING MACHINE.
(*I. Braithwaite and Son, Ltd.*).

Curtain Finishing.—In order to prevent unequal contraction during the drying of starched curtains, it is customary to attach them to frames, of which there are two well-known types, termed horizontal and vertical frames respectively, according to the position they occupy in the drying chamber.

The horizontal type is the oldest; it consists of a rectangular framework of wood, on two sides of which are fixed brass or steel pins. Attached to the framework are two movable cross pieces,

one in each direction. These are also fitted with pins and with a locking arrangement which enables curtains of different sizes to be readily placed into position. Several frames are necessary when dealing with large quantities of curtains; they are usually sent out in "sets" of about six or more, a drying box of the required capacity being also provided. In this arrangement, one frame is removed from the box at a time, the curtain taken off

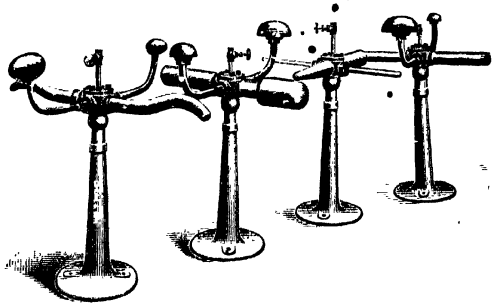


FIG. 124.—STEAM BOLTS.
(D. Gorrie and Son).

and replaced by another. A second frame is then removed and the re-loaded frame introduced into the oven and so on alternately. Fig. 125 shows a curtain drying arrangement of the foregoing type. The drying box is heated by steam pipes placed near the floor and no fan is used, as it is found that the artificial circulation of

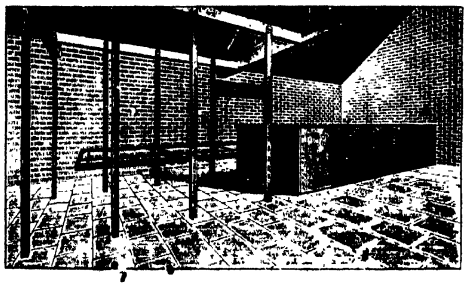


FIG. 125.—HORIZONTAL CURTAIN FRAMES.
(W. Summerscales and Sons, Ltd.).

air causes dust and other impurities to settle on the goods. Outside the box are upright supports to which are fitted small rollers for the purpose of enabling the frames to be readily moved in and

out of the box, the curtains being attached at the same level as they are drawn out. An improved loading and unloading arrangement is now made by means of which any of the frames can be readily adjusted to a suitable working height. In the interior of the box are several sets of rollers corresponding to the number of frames in use and upon these the latter rest during drying. Horizontal frames occupy a greater space for a given output than vertical frames, but they are still used to a considerable extent.

The vertical type of frame is usually fitted with a flanged wheel at each end, and these wheels rest on an overhead track which leads into the drying box. Movable vertical and horizontal rails which are fastened into position by means of thumbscrews are provided for the frames, as well as the necessary "pinning." An additional rail on which is a double set of "pinning" is sometimes provided so that two sets of narrow curtains can be dried at the same time.

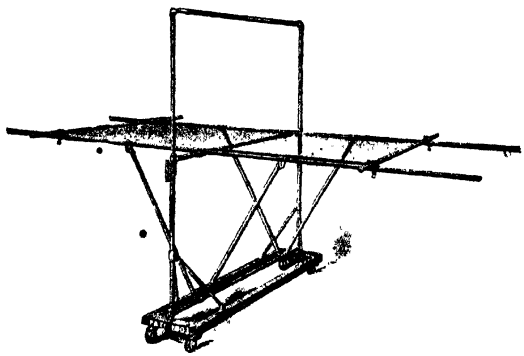


FIG. 126.—"TROY" CURTAIN TRUCK. OPEN.
(*J. Armstrong and Co., Ltd.*).

The "Troy" Curtain Truck.—An American arrangement for stretching curtains into position previous to drying is shown in Fig. 126. In this appliance the curtain is fastened by means of hooks to a movable metal framework in a horizontal position as shown in the figure. The centre bar is then raised to within a short distance of the top of the outer support and at this stage the side pieces are turned down so that the curtain is folded in the centre; the truck, which forms part of the apparatus, is then ready to be introduced into the drying cabinet. Fig. 127 illustrates the arrangement of the apparatus after the curtain has been folded in the centre.

Curtains without frills are removed from the frames while still damp; if allowed to become dry they should be dampened and rolled up for a short time. They are then either ironed by hand or passed through the decoudun; curtains with frills are hand-ironed and the frills finished by machine goffering or with the aid of hand irons.

The Finishing of Woollen and Silk Goods.—Articles of wear composed of wool or silk do not, as a rule, receive any special treatment in finishing. Starch and other substances which are of the highest importance in cotton and linen finishing, are rarely used, as such substances have a tendency to degrade the natural lustre and "handle" of the fibres.

A brighter appearance is imparted to silk articles, and "scroop" induced by giving them a final rinse in a weak solution of an acid such as acetic.

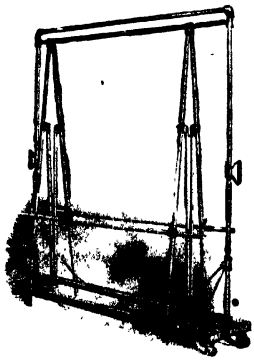


FIG. 127.—"TROY" CURTAIN TRUCK. CLOSED.

(J. Armstrong and Co., Ltd.).

Many woollen articles are simply washed, wrung, well shaken out, and carefully dried, but their appearance is considerably enhanced by subjecting them to a light pressing after drying.

Underwear and fine goods are generally ironed by hand after drying, the temperature of the iron being comparatively low. In many works, however, it is now customary to steam such goods, by means of a steaming table, and finally to "touch up" by hand ironing. A typical steaming table is shown in Fig. 128. It consists of a hollow metal table perforated on top, and supported upon a heavy cast iron stand. Steam is admitted into the interior of the table through suitable connections, which communicate with outlets for the removal of water produced by condensation. When in use, the table is covered with a layer of asbestos, on top of which

is laid a piece of felt which is in turn covered with cotton cloth. The part of the article to be steamed is placed on top of the covered table and steam admitted into the interior, from which it passes by way of the perforations through the padding and material undergoing treatment. Thus, the articles are rendered more or less plastic and can be easily straightened out, and, if necessary, pulled into shape. A broad padded piece of wood, to which is attached a handle, is used to lightly press out all creases. The action of the steam causes the fibres to become slightly "raised" and the goods exhibit a better appearance and possess a "softer" handle than can be obtained without steaming.

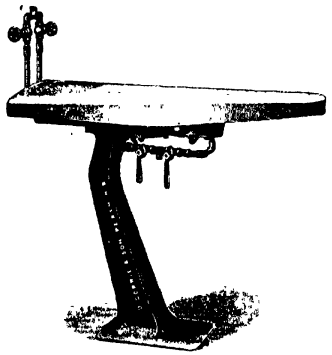


FIG. 123.—STEAMING TABLE.
(*D. Gorrie and Son*).

In high-class laundries, steam presses similar to those used by hosiery manufacturers are sometimes employed for pressing stockings, woollen shirts, etc. One of the best known machines working on this principle consists of a suitable framework supporting two flat steam-heated beds above which is fixed a powerful screw. The goods to be pressed are first placed upon flat wooden "shapes" or "stretchers" specially made for the purpose. These "shapes," with the goods in position, are then placed between the beds of the machine, and subjected to a short pressing action. The steam pressure in the beds should not exceed 20 lbs. per square inch. In this mode of finishing, the articles acquire an appearance similar to that exhibited by new goods.

CHAPTER II.

The Removal of Stains.

Perhaps no other subject has been so often discussed in the various textile journals as that of removing stains from the different fibres. Innumerable methods have been advocated—especially for use in laundry work—many of which appear to be unnecessarily complicated and entirely unsuitable for the purpose in view. The fact that there is still considerable diversity of opinion amongst practical launderers concerning the best method to adopt in each case, seems to be principally due to the absence of a sufficient knowledge of the chemical and physical properties of the materials available and their behaviour towards fibres.

The fundamental principles underlying the removal of the great majority of stains are both chemical and physical. For example:—When an ordinary iron stain is acted upon by oxalic acid, readily soluble iron oxalate is formed which is easily removed on washing with water. Here the underlying principles are chemical, (formation of iron oxalate), and physical, (removal of product by washing). The removal of a mineral oil stain, however, by acting upon it with an organic solvent is essentially due to physical action only, *i.e.*, dissolution and mechanical removal of product.

Stains on textile materials usually occur in the form of patches or streaks of greater or less width. They are generally characterised by the exhibition of colour which is quite distinct, as a rule, from that exhibited by the material on which they occur; hence the greater the contrast between the latter and the stains, the more prominent do they appear.

It is a common experience in most laundries to find that many stains are but little affected—if at all—during the usual washing process. On the other hand, a considerable number of stains are completely removed, especially when a hypochlorite is used in one of the operations, and it is on this account that goods are not often treated for stains before washing.

In bad cases, however, it is customary to steep the articles—it of white linen or cotton—in a cold weak solution of sodium hypochlorite for a short time before washing, a wooden tank being used for the purpose. The goods are subsequently soured in weak acetic acid solution, rinsed, and washed in the usual way. This

method may be adopted with advantage after washing, especially in cases where it is considered undesirable to employ a "chlorine bleach" at a high temperature.

As might be expected, the stains with which the launderer has to deal, are more numerous and of a more variable nature, than those met with in practically all other branches of the textile industry. In addition, the fact that stains occur on all kinds of fibrous materials introduces problems of a more or less complex nature, and calls for considerable experience and knowledge on the part of the operator who superintends work of this nature.

If it were possible to determine by simple means the nature and origin of each stain met with, its removal would be very much simplified, but this cannot always be done. Hence, the launderer adopts the method which he considers most suitable, and it not infrequently happens, that, sooner or later, the fabric becomes quite tender at the part or parts which have been treated for the removal of the stains.

The commonest stains met with in laundering practice are due to the presence of, or colouring matters derived from the following substances, viz. :—Blood, tea, coffee, fruit, iron, ink, dye, paint, grass, etc., etc.; all of which exhibit colour of one kind or another.

Blood Stains.—As a rule these do not offer much difficulty. They are removed from cotton and linen more or less completely during the alkaline breakdown of the washing process, and when present in considerable quantity, the latter should include a treatment with a hypochlorite.

Blood stains on animal fibres may be removed by a lukewarm solution of soap containing ammonia. Refractory stains should be treated with warm methylated spirit.

Tea, Coffee, and Fruit Stains.—These are generally removed from cotton and linen goods in the washing process, but sodium hypochlorite or perborate has frequently to be employed at one stage or another in order to ensure complete decolourisation. Stains on coloured or parti-coloured goods need to be treated with great care. A small portion of the hem of the article should be cut off and moistened with weak sodium hypochlorite in order to note its effect upon the colour or colours present. If the dye is unaffected, the stains should next be treated, and the parts subsequently given a thorough rinse in water. If the stains are not acted upon by sodium hypochlorite, they should be treated with a reducing agent such as acidified bisulphite of soda, or sodium hydrosulphite, taking similar precautions to determine whether the dye with which the material has been dyed or printed

is sensitive to reducing agents or not. Stains of the above nature —if still present after washing—are removed from white animal fibres by means of a bleaching process with hydrogen peroxide or warm sodium perborate in weak acetic acid solution. Stains on coloured or parti-coloured animal fibres should be treated either with hydrogen peroxide, or with Decroline, Hyraldite, etc., but the colour effects exhibited by the articles other than the stains, should first be tested as in the foregoing method, in order to find if they resist oxidising or reducing agents. Warm methylated spirit is very useful in cases where the above methods are inapplicable.

Iron Stains.—Stains caused by wet goods having been in contact with iron for a short time, or similar stains produced in other ways, are of frequent occurrence in most laundries. In many cases they are associated with other impurities, such as oil and dirt. Ordinary iron stains are removed from both vegetable and animal fibres by means of a fairly strong and warm aqueous solution of oxalic acid. The acid—in powder form—is sometimes spread on the moistened stains and allowed to remain until they have more or less completely disappeared. All goods should be thoroughly rinsed after treatment with oxalic acid. If the latter has little or no effect, a weak cold solution of hydrochloric acid should be tried, taking care to rinse thoroughly as before. In obstinate cases, a preliminary steeping in a solution of a strong reducing agent followed by one of the methods given above often proves efficacious.

Ink Stains.—These may be caused either by marking, writing, or copying inks. The marking inks generally employed are of two kinds, viz. :—1. Those containing salts of silver, and 2. Aniline black inks. The removal of ink marks caused by the use of the former depends upon the fact that silver readily forms a soluble double salt with potassium cyanide, (KCN), viz. :— KCN.AgCN. The stained portions of the articles are simply moistened with a weak aqueous solution of potassium cyanide and thoroughly rinsed so soon as the stains have disappeared. Potassium cyanide should be used with great caution, as it is one of the most powerful poisons known. Stains caused by the use of aniline black inks offer considerable resistance towards the ordinary reagents employed by the launderer. A mark made with good ink is very little affected either by reducing or oxidising agents, and, as it consists essentially of an organic pigment, which in many cases, has been developed on the fibre, its removal is principally dependent upon its behaviour towards various organic solvents. A liquid sold for the purpose was found on examination

to consist essentially of aniline mixed with a comparatively small quantity of nitro-benzene.

Writing Ink Stains.—Inks used for writing purposes are often made from various tannin substances and salts of iron. The stains which they produce may be removed from all fibres by means of a warm aqueous solution of oxalic acid.

Coloured writing ink stains are generally removed during the washing process. Such inks consist of aqueous solutions of coal-tar dyes thickened with gum or other suitable substance. Stains which resist the washing process should be treated with hydrosulphite, but coloured goods need to be previously tested as described in the paragraph dealing with tea, coffee, and fruit stains.

Copying ink stains are not often met with after washing, since the dyes with which they are coloured are readily decolourised in presence of alkaline solutions. They consist essentially of solutions of basic dyes thickened with gum or glue, to which a little glycerine has been added. When present on coloured goods or animal fibres which need to be treated with great care, a weak warm solution of ammonia usually effects their removal.

Mineral Oil and Grease Stains.—Many stains of this nature are removed during the washing process owing to the emulsifying action of soap. Stains caused by the presence of unsaponifiable matter, however, usually offer great resistance, and in such cases the local application of an organic solvent such as chloroform, benzine, or benzol, yields satisfactory results. It not infrequently happens, that mineral oil stains are associated with a greater or less amount of iron and dirt, so that if evidence of the presence of iron is obtained, the stained parts should be further treated according to one or other of the methods described under iron stains.

Paint, Tar, and Varnish Stains.—All stains which appear to have been caused by paint, tar, varnish, etc., and which resist the action of benzine and chloroform should be treated with turpentine, carbon tetrachloride, ether, warm methylated spirit, or benzol. Most of the organic solvents mentioned have low boiling points and are very inflammable, so that they should be used with great caution. In the majority of laundries, it is not customary to keep a stock of special substances for the purpose of removing stains. Indeed, it seldom happens that any organic solvents other than turpentine and methylated spirit are used, while the ordinary reagents are usually confined to the substances employed in washing and bleaching. Hence, stains which resist these substances are in many cases not further treated.

Dye Stains.—Many coloured stains on white linen and cotton goods due to the presence of dyes are removed during the washing process. Others are removed by the use of sodium hypochlorite or perborate. In the case of stains which are unaffected by alkaline detergents and oxidising agents, recourse must be had to one of the hydrosulphite compounds, such as Hyraldite Z, Decroline, or Hydrosulphite A.Z. A little of the powder is scattered over the stained part of the material which has been previously heated by immersion in a hot weak solution of acetic acid.

A solution of titanium chloride is also serviceable in many cases. It should be used cold and the stained parts of the goods immersed for a few minutes. Organic dye stains on white animal fibres which resist ammonia should be treated with one of the hydrosulphite compounds mentioned above, but with goods containing colour effects, the precaution of ascertaining the effect of the reducing agent employed on the dyes should first be adopted.

Grass Stains.—These are caused by the presence of chlorophyll, which is the name given to the green colouring matter present in most forms of vegetable life. Chlorophyll is readily soluble in ether, a property which suggests a means of removing it from fibres.

CHAPTER III.

Trade Laundry Work.

The term "Trade Laundry Work" is used here to indicate a section of the laundering industry in which only newly manufactured articles are cleansed and finished.

Reference has previously been made to two distinct branches of work of this nature, and it has been pointed out that in one branch, new collars, cuffs, fronts, and shirts which need to be highly stiffened are dealt with exclusively, while in the other branch only such articles as require a soft finish are treated.

The goods handled in both branches are contaminated with various impurities acquired during the cutting, sewing, and other operations; in addition, they generally contain a greater or less amount of starch which has been introduced during the finishing process to which all linen and cotton cloth used in the manufacture of detached articles is subjected before it is sent out to the manufacturer.

The objects and underlying principles of Trade Laundry Work will be more fully understood if we preface our description of the various operations carried on in each branch with a brief account of the manufacturing processes.

Manufacture of Collars, Cuffs, etc.—New white or coloured articles of wear which need to be highly stiffened are made from linen and cotton cloth which has been previously bleached and finished. Different amounts and qualities of cloth are used according to the kind of collar, cuff, etc., to be made. Articles which have to be very stiff when finished are often made from four thicknesses of cloth, but a more usual custom is to employ three thicknesses, *i.e.*, three ply, as it is found that a certain amount of pliability is sacrificed with each additional layer. The inner piece of cloth used in the manufacture of a stiff article is called the lining; the part which is exposed to view when worn is the front or "face"—known technically as the "fine"—while the other part is termed the "back."

In the case of a double collar we may distinguish between the "top" and "band"; the latter is the part containing the stud holes, and is stamped on one side with the size, trade mark, etc. Part of the "top," is the "face" or "fine," *i.e.*, the

portion which is exposed to view when worn. Four kinds of collars, cuffs, etc., may be enumerated, viz. :—

1. Those made entirely of linen.
2. Articles with the exterior parts of linen, and the linings of cotton.
3. Goods with "faces" only of linen and the other parts of cotton.
4. Articles made entirely of cotton.

Union cloth, *i.e.*, cloth with a linen weft and cotton warp is also employed to a limited extent. It is considered by some authorities, however, that many-fold stiff goods made from this material possess wearing properties which are not much superior to those possessed by goods made wholly of cotton, while, since the price of the former is more than half that of linen, it appears as if little advantage is gained by its use.

The linen cloth generally used, varies in quality from 13^{00} to 22^{00}, *i.e.*, the number of splits in 40 inches (width of cloth) varies from 1,300 to 2,200; and, as each split is made up of two threads, it follows that a 22^{00} cloth contains $2{,}200 \times 2 = 4{,}400$ threads in a width of 40 inches, whereas a 13^{00} cloth is much coarser, inasmuch as it only contains $1{,}300 \times 2 = 2{,}600$ threads in the same width. It rarely contains any finishing substances other than starch and oily softening agents. The cotton cloth should be free from weighting substances of all kinds, since their presence may give rise to considerable trouble in the subsequent cleansing process. Cloth which has been unduly stretched should be avoided, as it readily shrinks so soon as the manufactured articles are subjected to operations involving the employment of liquids at high temperatures.

In American shirt, collar, and cuff factories, it is customary to shrink both the linen and cotton by means of a steaming process, before the cloth is cut up into the various articles. Thus unequal shrinkage is more or less completely prevented. As a general rule, however, it is necessary to make an allowance for shrinkage—especially with cotton—by cutting the parts of the articles a little larger than the measurements when finished. The first operation in the manufacture of such goods as collars, cuffs, etc., may be termed "cutting out." It is carried on as follows :—

A zinc plate as wide as the cloth used and of the approximate length of the "faces" or linings, etc., of the articles to be made, is placed on the end of a long piece of cloth, and, after arranging the latter in position, turned over and over until a sufficient number of layers have been wound upon it. As a general rule, two dozen layers of cloth are wound at a time; the plate is then

removed and another two dozen wound, and so on. After the cloth has been arranged in this way, it is next prepared for cutting by placing a piece of metal of the shape of the "face" or lining, as the case may be, on the topmost layer, and the whole strongly clamped to a "cutting bench." The heap of layers of cloth is then cut round the metal shape with an exceedingly sharp shoulder knife, the handle of which rests on the shoulder of the operator, so that a more powerful cut can be made. Considerable experience is necessary when cutting out the cloth in order to ensure a minimum of waste. As already stated, the kind of material employed depends upon the class of collar, etc., to be made. For example:—If it is desired to make two dozen three-ply collars with the "faces" and "backs" of linen and the linings of cotton, 72 individual pieces of cloth will be required, and of these it is obvious that two-thirds must be linen and the remainder cotton. In pointed, *i.e.*, wing point collars, the linings are cut short near the points, while in four-ply articles one of the pieces forming the lining in each collar, etc., is cut smaller than the other parts and is not sewn. Fronts are frequently cut out from a heap of layers of cloth by means of a band-saw, the shapes having previously been marked with pencil on the top layer. Indeed, in some works all goods are cut in this way. After "cutting out," the individual pieces of cloth are ready for assembling in proper order and "basting," which latter operation is done by mechanical means. In "basting," the edges of the pieces of cloth are turned down about ¼ inch, the metal shapes referred to above being purposely made a little larger than the finished collars to compensate for the "turning-down." In the case of a three-ply collar, the three pieces of "basted" cloth are next arranged in position one on top of the other, the "basted" parts of the "back" and "face" being placed together with the lining between. The pieces are kept in position until ready for sewing by slightly pasting the edges with starch paste, or by means of pins. If paste is used care should be taken to see that it is of good quality and that it is not likely to mildew in the event of the articles having to lie for some time, for cases are on record which show that the greatest difficulty is experienced in the removal of mildew produced in this way. The three basted edges are next sewn together by means of high speed sewing machines, and the button-holes cut and sewn concurrently by power machines specially designed for the purpose.

The completed collar is then marked or stamped on the back with the size, trade mark, and other particulars. Aniline black paste or ink is commonly used for stamping new goods, and the

operation is carried on by hand, either rubber or brass stamps being employed. Since many proprietary marking inks contain free mineral acid, it is necessary to exercise considerable care in order to prevent the stamped parts from becoming tender. The goods should be washed as soon as the ink is dry, and on no account should the drying be facilitated by the application of a hot iron.

A stamping paste which gives good results can be made according to the following instructions:—

No. 1 Mixture.

Dissolve:—

8 ozs. chlorate of soda and $\frac{3}{4}$ oz. sulphate of copper in $\frac{1}{2}$ gallon of water. Add

$\frac{3}{4}$ lb. starch and boil; cool and add

1 pint acetate of aluminum 15° Tw.

No. 2 Mixture.

Dissolve:—

1 lb. 5 ozs. aniline salt in

1 quart of boiling water.

Thicken with about $\frac{1}{2}$-$\frac{3}{4}$ lb. starch and allow to cool.

For use, take equal parts of No. 1 and No. 2, and thoroughly mix. The printing paste is of a greenish colour when first mixed but rapidly changes to a black if subjected to moist heat. It is the custom, therefore, when this type of paste is employed, to place the goods, after stamping, on shelves in the interior of a suitable oven usually heated by gas.

Silver marking ink is sometimes employed in place of aniline black. It offers the advantage that it can be easily removed in the event of the goods being accidentally stained, whereas it is almost impossible to remove fully developed aniline black without tendering the material.

The stamps used with the above paste should be of copper or rubber and the operators should not stamp more articles than can be conveniently washed each day, since it is inadvisable to allow goods containing aniline black to lie about for more than an hour or two.

In American laundries the goods are usually stamped—before sewing—with the aid of ingenious stamping machines.

The Laundering Operations.—After stamping, the goods are taken in hand by the launderer, who subjects them to several operations identical in most respects with those fully described in a preceding chapter. In many cases, the washing process

is not nearly so stringent as in the case of similar goods which have already been in use, and a bleaching operation is frequently omitted. In most works, however, it is customary to adopt a somewhat lengthy and fairly drastic treatment in cleansing new goods, inasmuch as considerable difficulty is often experienced in the production of a uniform white on all the articles in the machine, especially in the vicinity of the seams. This is accounted for by the fact that the latter are often sewn with thread which has become contaminated with oil derived from the sewing machines. Traces of iron are commonly associated with the oil, especially if it has been long in contact with the metal parts of the machine, and it not infrequently happens, that the seams of articles made up of many folds exhibit a distinct yellowish tinge, which is directly traceable to the presence of lubricating oil containing iron and dirt.

The nature of the oil used for lubricating purposes is of considerable importance in view of the difficulty mentioned above. If it is of mineral origin, *i.e.*, unsaponifiable, it can only be removed from stained articles with difficulty; if, on the other hand, it is derived from vegetable sources, its removal from textiles is a comparatively simple matter, while a mixture of mineral and vegetable oils, *i.e.*, so-called stainless oil, offers little resistance to the usual washing process. Oils of this nature are now largely employed in textile factories in order that they may be more readily removed, if by any chance the articles undergoing the process of manufacture become soiled by their presence. Even stainless oils, however, form unsaponifiable films if exposed long enough to the air, so that collars which are contaminated with such oils should be washed as soon as possible. The use of vegetable oils alone for lubricating purposes is inadmissible in most cases, owing to their expensive nature, as well as on account of the difficulty of preventing them from oxidising and becoming thick when exposed to air under the conditions which obtain in practice. It may also be mentioned that the presence of free acid in a vegetable oil, either used alone or in admixture with a mineral oil, is an important factor in determining its value for lubricating purposes, in cases where there is danger of the goods becoming stained during the manufacturing operations. The greater the degree of acidity, the more powerful is the action exerted by the oil on the metal with which it is in contact.

Apart, however, from defects caused by the presence of unsaponifiable oils, it is well known that foreign matter of any kind is more difficult to remove from the seams of many-fold articles, than from other parts, owing to the resistance which the

former offer towards the penetration of the detergents employed. It has been previously mentioned, that, in addition to the impurities acquired during manufacturing operations, "new work" usually contains a greater or less amount of starch, and it is well known that this substance is not very readily affected by alkaline cleansing agents. Its complete removal is best effected by subjecting the goods to a preliminary treatment with one of the commercial malt extract preparations, a mode of procedure which possesses a further advantage, in that it facilitates the removal of other impurities in the subsequent wash, owing to the greater readiness with which the starch-free fibres are penetrated by the detergents.

Two examples are given below to illustrate washing processes for new collars, cuffs, etc.

Example 1:—

1. Breakdown for 10 minutes. Use cold water + 1½ gallons stock soda solution. Remove liquor, and rinse in cold water for 5 minutes.
2. First suds. Use cold water ⅓rd up gauge glass, and add 1½ gallons stock soda solution and 2 gallons soap solution. Raise temperature of liquor to 160°F. in about 15 minutes, and work at that temperature for 10 minutes. Remove waste suds.
3. Second suds. Use warm water ⅓rd up gauge glass, and add 2 gallons stock soda solution and 2½ gallons stock soap solution. Raise liquor to the boil in 10-15 minutes and boil for 10-15 minutes. Remove waste liquor.
4. Rinse in hot water for 5-10 minutes. Water ⅞ths up gauge glass.
5. Rinse again in warm water, ⅞ths up gauge glass.

If it is necessary to bleach the goods, use a little sodium hypochlorite or other suitable "chlorine bleach" in No. 5 operation, after which a thorough rinse should be given, followed by a treatment with weak acetic acid. Finally the goods are rinsed, and—if necessary—blued.

Example 2:—

1. Breakdown for 10 minutes in warm water.
2. Treatment with malt extract for 10-20 minutes at about 110-120°F. Use 4-6 ozs. extract. Remove liquor.
3. Wash. Use cold water. Add 2-3 gallons stock soda solution and 3 gallons stock soap solution. Raise liquor to boiling point in about 15 minutes and boil 15-30 minutes. Remove waste liquor.
4. Rinse in hot water for 10 minutes.
5. Rinse in warm water for 5 minutes.
6. Rinse in cold water for 5 minutes.
7. Rinse in cold water and blue.

The goods may be bleached—if considered desirable—with sodium perborate, or hypochlorite, a small quantity being added to the wash, while a treatment with weak boiled starch according to the examples given under domestic laundering, is considered to be advantageous. The latter practice is especially suitable for

shirts, since the bodies of these will then yield a better "finish" on ironing. When a glossy "finish" is required a little soap or Japan wax emulsion should be mixed with the boiled starch.

There is considerable difference of opinion amongst practical launderers concerning the amount of alkali required in washing new goods. If the latter are stained with oil, it is certainly advisable to employ a larger percentage than in the absence of such impurities, but it appears that, in a large number of works, the amount used is out of all proportion to the results achieved. The presence of a reasonable quantity, undoubtedly facilitates the fibre lubricating and penetrative action of soap solution as well as increases its emulsifying power. On the other hand, it is well known that the use of an excessive quantity is injurious, since it induces a colour degradation of the fibres, and exerts a weakening influence upon them.

A good quality of curd soap, free from resin, should always be used for "new work."

After washing, the goods are hydro-extracted. They are then ready for the starching operation, which is conducted in different ways according to the nature of the starch mixture employed. For goods which need to be highly stiffened two distinct methods of starching are in use, one of which is dependent upon the use of so-called "double starch," while boiled starch is employed in the second method. The term "double starch" is used to indicate a mixture of raw and boiled starch, the proportion of each, as well as its nature, *i.e.*, whether wheat, rice, or maize, being commonly regarded by launderers as "trade secrets," and it is questionable whether any two new work launderers use the same formula in making up starch of this description.

"Double starch" is used in the majority of new work laundries in Great Britain and Ireland. It has been superseded, however, in the United States of America and also in Canada by boiled starch. On the Continent, "double starch" appears to be used to a considerable extent, and it has been stated that the well known "Berlin clear starch work" is produced with its aid. Each process will now be described.

The "Double Starch" Process.—The operations involved in the starching of new goods with "double starch" may be enumerated as follows:—

1. Impregnation with starch.
2. Removal of surplus starch and straightening out.
3. Rinsing.
4. Squeezing or hydro-extracting.

1. *Impregnation with Starch.*—In this operation the cleansed and hydro-extracted goods are agitated in a mixture of raw and boiled starch contained in a suitable machine. Several types of machines are in general use, but those which appear to give the most satisfactory results are of the non-reversing barrel and dip-wheel types. The operation is carried on in the same way as in the raw starch process, the goods remaining in the machine for about 30 minutes.

As mentioned above, the starch mixture employed varies considerably, but the following may be regarded as a typical example:—

No. 1 Mixture.

11½-12 lbs. maize starch.
15 gallons cold water.

Make the starch into a smooth mass with a little of the water and introduce into a "cooker." Then add the remainder of the water and boil until a perfectly homogeneous paste is obtained. Finally cool to about 100° F.

No. 2 Mixture.

21-24 lbs. rice starch.
10 lbs. wheat starch.
Mix thoroughly with
12 gallons cold water and add
7 lbs. borax (crystals) previously dissolved in
3 gallons hot water and cooled.
½ pint turpentine.

"Double starch" is made by mixing Nos. 1 and 2 in equal proportions and adding the necessary amount of blue. It is used at a temperature of about 100-110°F. If the goods to be treated need to exhibit a considerable amount of gloss, a suitable "glaze" is either added directly to the prepared starch, or is applied separately at one stage of the ironing process. Greater pliability is ensured by the addition of a small quantity of glycerine.

The mixture given below is suitable for shirts. It yields a moderate amount of gloss, and imparts a full, thick, and stiff feel.

No. 1 Mixture.

10 lbs. maize starch.
10 gallons water.
1½-2 lbs. Japan wax.

Proceed as in above example, and boil until a smooth paste is obtained.

No. 2 Mixture.

10 lbs. rice starch.
10 gallons cold water.
3-4 lbs. borax

Mix Nos. 1 and 2 in equal proportions for use. The mixture should be applied by means of a machine similar to that shown in Fig. 49, a steam pipe being provided in order to keep the starch at a medium temperature. A little glycerine may be added if considered desirable.

2. *Removal of Surplus Starch.*—The articles are removed from the starching machine by hand. According to the practice in some works, they are next spread out flat and passed between the rubber rollers of a power wringing machine under a moderate degree of pressure, the surplus starch being collected in a receiver for further use. Only about one-sixth of the total amount of starch introduced into the machine is taken up by the goods, so that the recovery of the excess and its further utilisation is of great importance.

3. *Rinsing.*—This operation is next taken in hand by operators who agitate the goods separately for a few seconds in a weak cold mixture of raw starch and water at about 2° Tw. The object of rinsing at this stage is to remove surface starch, which may be present in considerable amount, and if allowed to remain would obviously give rise to serious defects in the subsequent ironing process. The articles are transferred directly from the rinsing trough to a table upon which they are laid flat, one on top of the other, in bundles of about half a dozen, all creases being removed during the operation; they are then ready for the next operation, viz.:—Squeezing.

4. *Squeezing.*—As its name implies, squeezing accomplishes the same object as the corresponding operation of the raw starch process, but it differs from the latter in that it is conducted in such a way as to ensure absolute uniformity in starch penetration throughout the fibres, while at the same time, the different layers of cloth are thoroughly "set" and excess of moisture and starch removed in a special manner, so as to prevent the latter from contaminating the surface threads, and rendering possible the production of a finished article—without sticking to the ironing surfaces—characterised by the exhibition of a non-filled-up appearance. Further, in some cases, the articles are subjected to a preliminary immersion in boiling water immediately preceding the squeezing operation, so that a greater or less amount of raw starch is gelatinised and the goods more effectually "set," while the escape of air enclosed in the interstices of the articles is

facilitated. The presence of boiled starch in the starch mixture employed prevents the raw starch from "settling out" in the seams or other parts of the goods, thus enabling a full, stiff, and uniform "finish" to be obtained.

Squeezing is carried out as follows:—After rinsing, the articles are arranged in one or more small flat batches on a piece of thick absorbent woollen blanket or felt and wrapped up carefully by turning them over and over, taking care that the flat shape of each batch is retained. In the simplest method of squeezing, the articles are then passed between the rollers of a power driven wringing machine under medium pressure. In the second method alluded to above, the woollen cloth containing the goods, is taken in hand by an operator and immersed once or twice for a few seconds in boiling water contained in a trough placed beneath the squeezing rollers. It is then immediately passed between the rollers, upon which a heavy pressure is exerted. The rollers are usually made of iron lined with horizontal staves of wood and fitted with a copper collar at each end. The top roller is caused to revolve in a direction pointing away from the operator. In use, one end of the bundle of goods to be squeezed is first placed over the top roller and by means of a suitable guide is then carried between the "nip," the bundle finally emerging at the front of the machine. In this way, practically all danger associated with the use of a high pressure squeezing machine is eliminated. The articles are next opened out, and after the usual preliminary operations, are ready to be ironed according to one of the methods described on page 277.

The foregoing operations are subject to considerable modification in different works. A typical example of a modified process which has been largely adopted is given below:—

The collars are loosely tied together in dozens and starched in the usual way. Surplus starch is then removed by hand, and the articles thoroughly rinsed in a raw starch mixture about 2° Tw., kept at a temperature of about 120° F. They are next placed in a hydro-extractor, which is run at a medium speed for about an hour. Finally, the goods are removed, and taken in hand by operators who separate and straighten them out so as to render them fit for blocking. Shirt bosoms and cuffs are starched in a machine of the same type as that used in the raw starch process, Fig. 49, but provided with a small steam pipe for keeping the starch mixture at a medium temperature. After the operation is complete, the starch is thoroughly rubbed into the goods by hand, and excess removed. They are then dried, and subsequently rinsed in a weak raw starch mixture at about

120° F. The starched portions of the goods are again rubbed by hand, after which operation, they are rolled up carefully in thick woollen material and passed between the rollers of a squeezing machine under considerable pressure. At this stage they are ready for blocking.

Ironing.—The machines used for ironing goods which have been impregnated with "double starch" are identical with those employed in the raw starch process. It appears, however, that the ordinary form of steam press is not particularly well adapted for the blocking operation, inasmuch as there is considerable difficulty in rendering the surfaces of the goods uniform, this being due to the fact, that the operator is unable to control the progress of the operation in such a ready manner as is possible when a table ironing machine is used.

The complete and ready control of new work—which is usually badly creased—in the first stage of the ironing process is of the highest importance, and with this object in view, it is customary in many works to subject the goods to a preliminary blocking operation, on both sides, with the aid of a table ironing machine. The blocking and partial drying of the goods are then completed by means of a steam press, or a special form of roller drying machine, which is similar in principle to the roller glossing machine. At this stage, they are examined, and, if a high gloss is required, a little "glaze" in paste form is rubbed on by hand, using a clean piece of linen. After lying for an hour, the goods are glossed on a roller machine or with the aid of other suitable apparatus. Shirts are commonly blocked by hand and finally glossed on table machines.

The Boiled Starch Process.—It has been stated in a previous paragraph that both new work, and articles which have been in use are frequently starched with boiled starch only. The operations involved differ from those described above in several important particulars. In the first place, the actual starching operation is continuous, each article being fully starched in the course of a few seconds. Secondly, specially prepared starches known as thin-boiling starches are used, and in the third place, the additional operations of drying and subsequent dampening are essential.

From a consideration of the nature of the fibrous articles to be treated as well as the "finish" required, it is evident that the success of what may be termed an instantaneous process of starching goods composed of several folds is primarily dependent upon the facility with which the individual fibres can be impregnated with the starch. Now it is well known that the higher the viscosity

of a liquid mass and the higher its temperature, the more readily will it penetrate fibrous materials; hence, it naturally follows that a thin hot starch paste is more efficient in the matter of penetration than a thicker paste. It is to be observed, however, that a boiled starch paste made from ordinary starch must be comparatively thick, in order to impart the necessary "body" and stiffness to collars and similar goods. It appears from these observations, therefore, that ordinary starch is unsuitable for the continuous starching of goods composed of many folds, because on the one hand the penetrative power of a paste of low viscosity is not high enough for rapid work, while on the other hand a thin paste lacks the power of imparting the necessary amount of stiffness, etc. Consequently, with the introduction of continuous starching machines for goods which have to be highly stiffened, a demand arose for a starch from which a paste could be prepared of the requisite viscosity without sacrificing its property of imparting "body" and stiffness. Starches possessing these qualities in varying degrees are now manufactured in enormous quantities; they are termed "thin-boiling starches." A thin-boiling starch consists essentially of a partially hydrolysed starch, *i.e.*, a starch which has been partially converted into dextrin-like derivatives. It differs from ordinary starch in that an equal quantity yields a much thinner paste when boiled with a definite volume of water, and pastes possessing comparatively high viscosities can be prepared from some varieties, even when the starch-content is so high as 6 lbs. per gallon, whereas it is common knowledge that a very thick paste is obtainable with a comparatively low content of unaltered starch.

The mode of manufacture of "thin-boiling starches" has already been described on page 82, and it has been pointed out that, when these starches were first placed on the market, considerable difficulty was experienced in the manufacture of different batches of the same kind of starch that would give identical results in finishing. This lack of uniformity may be readily induced by using acid of varying degrees of strength; by working at different temperatures, or by increasing or diminishing the length of time of treatment. Most of the "thin-boiling starches" now made, however, leave nothing to be desired as regards unifomity, since the greatest care is taken to ensure that different batches are made under identical conditions.

The Starching Operation.—This takes place immediately after washing and hydro-extracting. The care with which the latter operation is carried out, has considerable influence on the uniformity of the "finish" imparted to different batches of goods.

This statement is also applicable to other starching processes. The machine should be loaded each time it is used with the same weight (approximately) of goods, and run for an equal length of time at the same rate of speed.

Tape or apron "starchers" are in general use for impregnating collars and cuffs with boiled starch, and two typical representatives are described and illustrated on pages 159-160. The particular starch chosen is boiled up with water, the proportion of each being governed by the nature of the starch and the kind of "finish" required. Other substances are frequently added to the paste in order to increase its lustre-producing properties, etc.

The following typical example illustrates the composition of a paste made from a thin-boiling wheat starch, but, as a general rule, it will be found, that the best results with thin-boiling starches are obtained by carrying out a few trials on a practical scale.

BOILED-STARCH PASTE FOR STIFF WORK.

Mix 20 lbs. of thin-boiling wheat starch with 20 gallons of water until free from lumps.
Raise to the boil while constantly stirring, and add 3-6 ozs. of Japan wax, and about 2½ lbs. of borax. Boil for about 10-15 minutes, and, if necessary, strain through calico before use.

The vessels in which the starch paste is made are commonly termed "starch cookers." Two kinds of "cookers" are in use. One type consists essentially of a copper pan provided with a steam jacket, and, in some cases, with mechanical agitators and a tilting arrangement. In this form, the starch paste is not diluted by the condensation of steam, as is the case when an open steam pipe is used for heating purposes. An ordinary closed copper steam coil placed at the bottom of the pan can be used instead of a jacket, one end of the coil being connected to the steam supply and the other to the nearest drain or a steam trap.

In the second type of "cooker," an open steam pipe is used, a separator being provided for the purpose of removing water from the steam as it passes into the pan. "Cookers" built on this principle are very largely used. A well-known apparatus is shown in Fig. 129. It consists of an inner vessel of copper and an outer vessel of galvanized iron. These are placed a small distance apart, one within the other, and the intervening space filled with a non-conducting material. The steam connections, separator, lid, and draw-off tap are shown in the illustration. Starch made in a vessel of this kind can be easily kept hot for a long time.

Wiping and Straightening Out.—The articles received at the exit end of the starching machine are coated with a considerable

amount of surface starch which must be removed before they are further treated. With this object in view, an operator lays each article out flat on a suitable table adjacent to the starching machine, and then brushes or wipes off the surplus starch; at the same time any creases are straightened out by the rubbing or

FIG. 129.—STARCH "COOKER."
(*J. Braithwaite and Son, Ltd.*).

brushing action. A small brush is often employed when the goods are badly creased, and a piece of clean linen under ordinary circumstances. "Straightening out" is sometimes termed "blocking."

Drying.—This operation is peculiar to the boiled starch process and must be conducted as rapidly as possible in order to obtain uniformity in the finished articles. Types of drying apparatus specially adapted for work of this nature are described in Section IV., Part I. The temperature at which drying takes place, varies to a certain extent in different laundries, but it is usually not much lower than 200° F. As soon as the goods are dry, they should be immediately removed from the drying room, since too long an exposure at a high temperature has a tendency to cause them to acquire a yellowish tinge which is very objectionable.

It is also considered by some authorities, that this system of drying exerts a deteriorating influence upon their tensile strength, but no systematic investigation appears to have been made with the object of ascertaining whether this statement is correct or not.

Dampening.—All goods which have been starched with boiled starch and then thoroughly dried need to be dampened before ironing. This operation is sometimes known as "conditioning." Its object is to moisten the goods evenly with a certain amount of water, without which, the production of a lustrous and uniform "finish" is impossible. The action of water in conditioning dried starched goods is manifold. In the first place, it restores the inherent pliability of the fibres; secondly, it renders the starch more or less plastic, thus enabling all creases produced by unequal contraction during drying to be removed; thirdly, it minimises the danger of scorching during ironing, and in the fourth place, it enables the starched threads to be readily moulded into shape and flattened on the surfaces at the temperature of the ironing operation, so that gloss is produced without any pronounced diminution in the tensile strength of the goods.

Several types of machines are in use for dampening heavily starched goods, the best known being of American origin. In practice, the goods are first dampened by a passage through one of these machines, and then subjected to pressure in a "dampening press" for about an hour. The latter operation ensures uniformity in the distribution of moisture throughout the fibres.

All dampening operations call for the exercise of great care, in order to prevent widely varying amounts of moisture being absorbed by successive batches of goods. In all cases, excess of moisture is to be avoided, as this throws additional work on the operators, and causes unnecessary wear and tear of the goods and machines. In practice, the aim is to moisten the goods to the smallest possible extent, consistent with the production of a satisfactory "finish."

A type of dampener specially designed for collars and cuffs is illustrated in Fig. 130. It consists of a suitable stand supporting three pairs of rollers, each pair differing in diameter from the other pairs. The two largest, *i.e.*, the dampening rollers, are covered with rubber, and the collars, etc., pass directly between them into a receiver placed beneath the machine. One of the rollers is fixed in position, but the other can be readily adjusted according to requirements. Each of the second pair of rollers (B), works in a copper pan containing water, and is in contact with one of the dampening rollers. The level of the water in the pan is kept at a constant level by means of a simple automatic device. The third pair of rollers act as strippers, *i.e.*, they remove excess

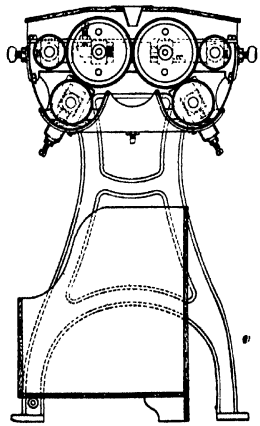


FIG. 130.—COLLAR AND CUFF DAMPENER. SECTIONAL END VIEW.
(I. Braithwaite and Son, Ltd.).

of water from the dampening rollers by pressing against them. Each roller may be actuated separately, so that different amounts of moisture can be pressed into the goods during their passage between the dampening rollers. A collar and cuff dampener differing in several details from the above is shown in Fig. 131. Its chief points of difference are as follows:—In the first place the number of rollers is reduced to three. Secondly, the dampening roller is of brass covered with cotton cloth. This roller revolves in a copper water tank in which it is partly immersed, so that the cotton covering becomes thoroughly saturated with water. By means of an adjustable stripper roller which presses against the dampening roller, the amount of water retained by the cotton

can be easily regulated. Finally, the third point of difference is evident from the grooved appearance of the upper roller, which latter also presses against the dampening roller. Moisture is squeezed into the goods by passing them between the grooved roller and the cotton covered roller, the mode of construction of the former effectually preventing the formation of a band of water at the point of contact of the two rollers on the feed side of the machine.

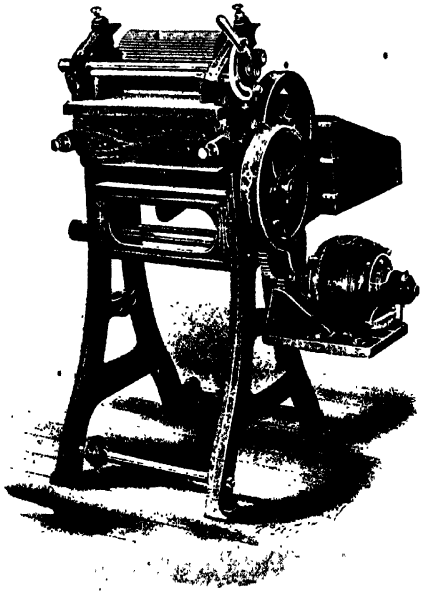


FIG. 131.—COLLAR AND CUFF DAMPENER.
(*I. Braithwaite and Son, Ltd.*).

Ironing.—One of the chief advantages claimed for the boiled starch process, is the rapidity with which the ironing process is completed. Indeed it is with this object in view, that the goods are dampened as lightly as possible. Ironing is conducted on one of the various types of multiple roller collar and cuff ironers, either gas and air, or steam being used for heating the rollers. As a rule, one passage through a suitable machine is sufficient to finish the goods. Obviously, the greatest possible care needs to be exercised in straightening out the articles before they are fed into

the machine, or they are almost certain to be creased, while if too much moisture is present, owing to inefficient dampening, the goods exhibit a tendency to stick to the heated rollers, and cannot be finished properly by a single passage.

The ironers are commonly made with interchangeable gear, so that a domestic or medium gloss can be obtained at will, while some machines are specially designed for imparting a high-gloss finish.

General Remarks.—The boiled starch process for new and old work, has met only with a comparatively small amount of support in British laundries, although its adoption has long been universal in America. Advocates of the process claim that, in certain respects, it is superior to either the "double," or raw starch process, while on the other hand, many authorities maintain that any advantages it may possess are counterbalanced by disadvantages. As a result, the relative merits of each process have long been, and are still, subject to keen controversy in the trade. The chief distinguishing features of both processes are tabulated below, and it should be noted, that the statements which follow, concerning the use of boiled starch for new work, apply with almost equal force to the boiled starch process for domestic work. Similarly, the main features of the "double starch" process for new work, are practically the same as those which are characteristic of the raw starch process for goods that have already been in use.

COMPARISON OF THE CHIEF FEATURES OF THE "DOUBLE" AND BOILED STARCH PROCESSES AS USED FOR COLLARS AND CUFFS.

"Double Starch" Process.	Boiled Starch Process.
1. Comparatively simple and inexpensive starching machines are employed.	1. For successful and rapid work specially-designed starching machines are essential.
2. The starching operation takes up a considerable amount of time and exerts a weakening influence on the fibres.	2. The starching operation is completed in a few seconds, a comparatively small amount of friction being induced.
3. The goods have not to be dried after starching.	3. Each article has to be dried separately, and as quickly as possible.
4. Dampening is unnecessary.	4. The goods have to be dampened before ironing.
5. The ironing process takes up a greater amount of time than in the boiled starch process, and, at least, two types of machines are usually employed for the main operations.	5. Ironing is completed in the course of a few seconds, and is usually done with the aid of one machine.

Many practical launderers who have had experience both of the boiled and "double starch" processes, are of opinion, that

the rapid drying of starched articles at a fairly high temperature militates against the production of a good "colour," and it is well known, that, in many cases, it is essential to use considerable quantities of blue, both in the rinsing operation and during the actual starching operation, in order to obtain satisfactory results with the former process. This mode of procedure is rendered necessary owing to various causes. In the first place, traces of acid may be present in the boiled starch, with the result that the blue is more or less completely decolourised, at the temperature of the drying operation, assuming, of course, that the blue used is ultramarine. In the second place, the dextrin-like substances present in thin-boiling starches have a tendency to become yellowish in colour on heating, hence a considerable amount of blue is required in order to neutralise this effect; and in the third place, the fibres themselves exhibit a tendency to undergo a somewhat similar colour degradation under the conditions which obtain during drying.

It is also considered that more skill is required, as well as much more supervision, when starching with boiled starch, than is the case when using either "double" or raw starch.

Furthermore, it is generally admitted by trade launderers that the finished effects obtained by using "double starch" for stiff goods, are superior to those obtained with the aid of boiled starch, and it is well known that goods finished according to the latter process, soon become limp on storing. With regard to the former statement, it is of interest to note that manufacturers frequently meet customers in the home market who buy only those goods, which exhibit an appearance, and possess a "handle," considered to be obtainable only by the use of "double starch." On the other hand, advocates of the boiled starch process, maintain that almost any effect produced with the aid either of "double" or raw starch, can be produced by the use of boiled starch. It appears, however, that the consensus of opinion amongst practical launderers in this country, is opposed to the use of boiled starch for new stiff articles intended for the home market, although its use for similar, as well as old goods in American practice, undoubtedly gives just those results which are demanded by the American customer. In the first case, a thick, full, stiff and more or less lustrous article, possessing sufficient pliability to prevent discomfort when worn is required, whereas in the latter, a high degree of stiffness and lustre, and a thick "feel" are not of great importance, *i.e.*, a softer effect is required. The softer and less lustrous the "finish," the less is the average length of time that the articles can be worn; consequently, it would appear that

the boiled starch process is of considerable advantage when considered from a hygienic standpoint.

Another claim put forward in favour of the boiled starch process, is its greater economy in materials, wear and tear of machinery, and labour, while the principles upon which it is based are certainly more scientific than those underlying the use of raw starch. Still, so long as the average results obtained, are inferior to those yielded by the "double" and raw starch processes, it does not appear likely that the process will make much headway in this country, at any rate among the medium and small-sized laundries, and especially those in which high-class work is a speciality.

With reference to many of the statements which have been made from time to time concerning the merits or demerits of the chief starching processes in use, it is to be observed, that no attempt appears to have been made to base them on the results of trials carried out in a scientific manner, or on a careful consideration of the physical properties of the starch mixtures employed, and the nature of the fibres to be treated.

If the common physical properties of a raw starch suspension, and gelatinised starch respectively are compared, it will be evident that the threads of those articles undergoing a simple impregnation process are more or less readily penetrated by the minute granules of the former, whereas in the case of boiled starch, penetration of the threads is dependent to a greater or less extent upon the viscosity of the starch paste, the nature of the fabric, and the kind of yarn from which it has been made, *i.e.*, whether it is a hard or soft yarn. It follows, therefore, from these considerations, that the use of boiled starch for stiff goods, necessitates the employment of means for the purpose of forcing it into contact with, as well as between, the fibres of the threads of warp and weft, so that the necessary degree of stiffness can be obtained on ironing. The latter operation also causes the starch in the interstices between warp and weft threads to become stiff, hence the finished article consists essentially of such threads embedded in a matrix of starch. The integument produced in this way, consists essentially of an unbroken film of starch, covering both threads of warp and weft as well as the adjoining spaces, so that the finished article usually gives little indication of the kind of fabric that has been treated.

On the other hand, when a raw starch suspension is used, it does not fill up the spaces between warp and weft to the same extent, owing to its being devoid of mucilaginous properties; neither does the subsequent gelatinisation of the granules produce

such a "filled up" appearance of the spaces between warp and weft. Consequently, the threads of the finished article are more readily distinguished, and the articles do not appear to contain an excessive amount of foreign matter.

It may be concluded from the above statements regarding the simplicity of the way in which a raw starch suspension is taken up by a fabric, that the employment of mechanical means for the purpose of forcing the starch into the threads is unnecessary. Theoretically, this view is correct, in so far as it applies to a fabric which is open to the full action of the starch suspension, provided, of course, that the starch granules of the latter are equally distributed and prevented from "settling out" by suitable means, and that the threads of warp and weft are not too tightly twisted.

In general, however, goods which need to be highly stiffened, consist of many folds of cloth sewn together, and, as it is of the greatest importance, that the starch should penetrate the inner folds as well as the outer, it has been found in practice that a certain amount of force is necessary in order to accomplish this result in a satisfactory and uniform manner.

As previously explained in our description of the raw starch process, the means usually employed are of such a nature, that the goods are violently agitated and drenched from time to time with the raw-starch suspension. In this way the necessary force is provided to ensure thorough penetration, while at the same time, the starch granules are kept in a state of equal distribution throughout the mixture. This method of impregnating fibres with raw starch is undoubtedly severe on the goods compared with the method of applying boiled starch.

The principles underlying the impregnation of fibres with raw and boiled starch are also applicable in the case of "double starch." The presence of raw starch in the latter facilitates its distribution among the threads, and the finished articles possess a considerable amount of pliability and stiffness, as well as a full thick feel. It is to be noted, that goods treated with thin-boiling starches, develop pliability owing to the sacrifice—by the original starch—of those physical properties which distinguish it from the dextrins. In other words, a "finish" obtained with the aid of dextrin-like substances, possesses much more pliability than a pure starch "finish," the latter, of course, being characterised by a high degree of stiffness.

The Manufacture of Soft Finished Articles.—In a previous section we have dealt with the mode of manufacture of goods which need to be highly finished, and reference has been made to

the fact, that the degree of stiffness and other physical properties exhibited by such goods are partly dependent upon the number and quality of the folds of cloth from which they have been made.

Soft finished goods, on the other hand, are invariably made from single-ply cloth. In most cases, the edges are turned down and sewn, but the amount of dirt, etc., contracted during this and other operations is usually so small, that its subsequent removal gives rise to much less complex problems than those met with in the cleansing of goods made from several folds of different materials. It frequently happens, however, that certain classes of soft finished goods, *e.g.*, hand embroideries, are more difficult to cleanse than any other kind of "new work."

The various detached articles which need to be washed after the manufacturing operations, and subsequently finished in such a way as to cause them to possess a soft "handle," may be classified as follows:—Handkerchiefs; bed-spreads and sheets; tea and tray-cloths, doileys and similar articles; robes and blouses; pillow cases and shams; table cloths and serviettes; towels, etc. They may be conveniently divided into two main groups, viz.:—1. Plain goods, and 2. Embroideries. Under the term "plain goods" is included all articles which are either quite plain, or exhibit effects produced in the loom or by printing.

Manufacture of Plain Goods.—Plain articles are made in a comparatively simple manner. Bleached and finished cloth is first of all cut up according to the size of the article required. Plain handkerchiefs, certain kinds of towels, etc., etc., are usually hemstitched, while other articles such as ribbed handkerchiefs, table cloths, serviettes, etc., are turned up twice at the cut edges so as to form a very narrow hem which is subsequently sewn by machine. This is done in order to prevent the edges from fraying. Hemstitching accomplishes the same object, but at the same time, the effects produced in the various styles, such as punch, shire, and revere, are, of course, much more ornamental than those produced by means of very narrow hems.

Manufacture of Embroidered Goods.—Embroidery is the art of producing artistic patterns by means of needlework on textile fabrics. Two distinct classes of work may be recognised, viz.:—Hand embroidery and machine embroidery. The former includes all kinds of artistic needlework done by hand with white or coloured thread on white or coloured material, while the latter includes all work done by single or multiple-needle machines. The material on which the embroidery effects are usually produced is either cotton or linen, the latter being employed for high-class goods. Enormous quantities of cotton are used in the manufacture of

Swiss embroideries, while large quantities of the finer qualities of linen cloth are also used for the same purpose.

Hand Embroidery.—This is considered to be the best and is usually done by cottagers in country districts, the goods being distributed and collected by agents of the manufacturers. As a rule, work of this description is highly contaminated with all kinds of impurities, many of which frequently offer great resistance towards the various substances used in the subsequent washing, as well as towards the compounds employed for removing stains.

The embroidery patterns for hand or machine work (Swiss embroidery excepted) are first drawn on suitable paper by a designer. The drawing is then superimposed upon another piece of tough paper, and the two placed upon the table of a perforating machine. This consists of a suitable framework supporting a hollow brass standard to the top of which a movable arm is attached. The arm is double-jointed, the first portion being almost horizontal and the second portion vertical. The free end of the arm is arranged at a convenient working height. Beneath the framework is a large grooved pulley operated by a foot treadle. A fine cord passes round this pulley, and up the hollow standard to the top, where it passes round a second pulley. By means of intermediate pulleys, the cord is caused to actuate a miniature eccentric on the end of the swinging arm. Attached to the eccentric is a small nipple which holds a very fine needle. A small bracket or guide is also fitted to this part of the apparatus. In use, the guide rests lightly on the paper to be perforated, and the needle working up and down is guided over the design, thus reproducing the design in the form of pinholes very close together.

Having now prepared a pattern perforated on paper, the next step is to transfer it to the articles to be embroidered. This is accomplished by what is known as a "printing" operation, which is carried out as follows:—An operator places the paper pattern upon the article to be "printed," in such a way, that the perforations occupy the position which it is intended that the embroidery shall occupy. A paste composed of ultramarine blue and a suitable greasy thickening agent is employed for transferring the pattern to the cloth. The paste is taken up on the rubber end of a flat squeegee, and, while the paper pattern is kept in position on the article with the left hand, the blue paste is lightly forced through the perforations by the pressure of the squeegee, which is held in the right hand and drawn over the perforations. The "printed" pattern dries very quickly and the goods are then ready to be embroidered. In some cases the pattern is

transferred to the cloth by dusting a powdered carbon black through the perforations by means of a pad. For certain classes of work the ordinary black ink used by typographic printers is sometimes used for printing the embroidered patterns, but, as it is extremely difficult to remove, the greatest care should be exercised in order to avoid "printing" or staining parts of the material other than those intended for the embroidery. The ink is only slowly attacked during the subsequent washing operations, so that it is evident, that the result of using a paste of this nature for "printing" purposes is to cause the embroidery to be "thrown up" to a greater extent than would be the case if the pattern were removed. In other words the embroidery appears to be grey; hence it is more pronounced upon a white background than if it were white. This process is only adopted to a moderate extent and appears to be confined to certain classes of goods intended for the American market. Other kinds of black "printing" pastes have been advocated and used from time to time, but these need not be further considered, since the effects produced in this style of embroidery are not likely to continue in demand.

Machine Embroidery.—This is produced by means of single or multiple needle machines and appears to be gradually displacing hand embroidery for cheap goods. Very large quantities of cotton and linen articles such as bed-spreads, robes, handkerchiefs, etc., are embroidered by a type of machine which is not unlike an ordinary sewing machine in appearance, while special multiple needle machines are available which are capable of embroidering the same pattern, *e.g.*, a monogram, on several articles at one operation. In the manufacture of machine embroidery, the pattern is usually "printed" on the material according to the method described above, but in the case of goods of very thin texture, it is the practice to "print" the pattern on paper which is subsequently placed beneath the material to be embroidered, the pattern being sufficiently pronounced to enable the operator to follow its outline. When this method is adopted the usual after treatment for the removal of "printing ink" is, of course, unnecessary.

In other cases, thin material of good quality is "printed" with a pattern in the usual way and then superimposed on paper so that the needle of the machine passes through both cloth and paper. The use of the latter in this way, prevents the perforations in the cloth from becoming enlarged by the action of the needle. Paper is also used in a similar manner, in order that the embroidery may exhibit a more pronounced "raised" effect.

Swiss Embroidery.—This is manufactured with the aid of an ingenious machine which consists essentially of a modified form of the original Heileman's machine patented so long ago as 1829. With this style of machine, a large number of repeats of the pattern can be produced simultaneously. The pattern is gradually built up by the action of a pantograph attachment, the point of which moves over an enlarged copy of the design and at each stitch causes the frame carrying the needles to move into the requisite position for the production of the repeats of the pattern. Machines working on this principle are only suitable for the economical production of a large number of similar patterns at one operation. Swiss embroidery is manufactured on an enormous scale at St. Gall, in Switzerland. It is chiefly cut up into handkerchiefs, blouse fronts, and other articles of a similar nature.

In the manufacture of certain kinds of linen handkerchiefs, it is customary to send suitable bleached linen cloth from Belfast to St. Gall to be embroidered. It is then returned and subsequently cut up, hemstitched, and laundered. In order to dispense with the laundering process, some manufacturers have lately introduced a system whereby the goods are embroidered in the grey state, and then cut up, stitched, and finally bleached and finished. It will be obvious that a description of the latter mode of procedure is more suitable for inclusion in a work on bleaching, and we do not purpose dealing with it here.

The Laundering of Soft-Finished Goods.—It is evident from the foregoing account of the different manufacturing processes which are characteristic of the small goods industry, that the subsequent treatment of such goods in the laundry, must be modified from time to time according to their nature and condition. It is well known that a simple cleansing process suitable for plain handkerchiefs is not entirely satisfactory when used for hemstitched goods. Again, Swiss embroideries are comparatively easy to cleanse compared with hand embroideries, while the former offer less resistance towards the detergents employed than embroidery work done on the ordinary single or small multiple needle machines. The nature of the material—whether plain or embroidered—has also to be taken into account in deciding upon the best mode of procedure. As a general rule fine and delicate goods are not washed in rotary machines owing to the risk of damage by entanglement as well as by the rubbing action of the goods upon each other. In such cases, the usual practice in some of the best laundries, is to wash the articles entirely by hand, or —if hand embroideries—to give them a preliminary treatment in a weak boiling solution of sodium carbonate contained in a suit-

able tank, and then to complete the cleansing process by hand washing. A brief account of the methods in vogue for cleansing and finishing the more important classes of goods is given below.

Handkerchiefs.—These are cleansed either in rotary machines, tanks, or by hand in porcelain troughs. The former should only be used for goods of comparatively strong texture, while, as stated above, the finer articles should either be given a preliminary treatment in a tank with a boiling detergent, or washed entirely by hand. Ordinary plain and ribbed handkerchiefs, and Swiss embroideries containing white effects only, may be washed in a weak solution of "alkali" contained in the rotary machine, sufficient soap being added as ascertained by practice. The liquor is gradually raised to the boil and the goods boiled for about 15-20 minutes. They are then thoroughly rinsed, and, if necessary, bleached by steeping them in a weak solution of sodium hypochlorite for a short time, after which they are rinsed, blued, squeezed, or hydro-extracted, and finally ironed by hand. Sodium hypochlorite is frequently added to the contents of the washing machine as described in a previous chapter. Handkerchiefs with highly-coloured embroidery effects should be washed entirely by hand, and on no account should they be left lying about in the wet state, since the colours are almost certain to "run" under such conditions. Swiss goods containing tinted embroidery effects may be washed in the rotary machine, using a weak soap liquor at a medium temperature. They should not be allowed to come into contact with bleaching agents.

In the case of embroidered handkerchiefs which have been previously printed with ultramarine blue, the following mode of procedure in cleansing is commonly adopted:—

1. Breakdown; using a weak solution of alkali at a medium temperature.
2. Scald in machine or tank.
3. Wash by hand or machine.
4. Steep in oxalic acid solution and rinse.
5. Steep in sodium hypochlorite and then rinse.

1. *Breakdown.*—This operation is carried out by subjecting the goods to the action of sodium carbonate solution either in a rotary machine or tank for periods of about 10 and 20 minutes respectively the temperature of the liquor being kept at about 110° F. By this treatment, surface dirt and albuminous matter are removed and other impurities are rendered more amenable to the action of the detergents used in the subsequent operations. It is to be noted that the breakdown is frequently omitted in the treatment of new goods, as it is considered that foreign matter

which coagulates when the temperature of the liquor with which latter it is in contact reaches a certain point, is removed from the fibre long before the coagulation temperature is reached. Still, it is advisable to employ the breakdown especially for the treatment of hand embroideries. If the goods are first subjected to a boil in the rotary machine, however, a sufficient amount of soap should be added so as to prevent any extracted foreign matter from "settling out" on the goods. When tanks are used, the addition of soap is not essential, the goods being practically stationary during the boiling operation.

2. *Scalding.*—Handkerchiefs which have been previously "printed" and subsequently embroidered by hand, contain a greater amount of foreign matter than machine embroideries. They also retain most of the paste used for "printing" the pattern. In the case of machine embroideries, the impurities contracted consist essentially of oily matter and dirt, while those with which hand embroideries are contaminated are much more numerous and of a more complex and variable nature. The former class of goods are not difficult to cleanse provided that the articles are not allowed to lie about after the manufacturing process. Hand embroideries, however, cannot be satisfactorily cleansed without a more drastic treatment than any of those previously described. Hence, it is customary to boil or scald them in a fairly strong solution of "alkali" for some time and then to wash subsequently with soap.

Scalding or boiling in rotary machines is frequently carried on in a type of machine which admits of the goods being boiled under a few pounds steam pressure. A machine of this kind is illustrated and described on page 132. A solution of sodium carbonate of from ½ to 1° Tw. is introduced into the machine, along with sufficient soap solution to prevent the scum which is subsequently formed from settling in the hems or embroidery parts of the articles undergoing treatment. The duration of the scalding operation is primarily dependent upon the nature and condition of the goods, and may vary from about 20 to 40 minutes. The articles are then thoroughly rinsed. Subsequently they are given a final boil in a solution of a good soap and rinsed again in the usual way.

As previously stated, tanks are commonly employed for scalding hand embroideries. They are made of galvanized iron and are usually circular in shape. A false bottom perforated is fitted to each, and beneath it is placed an open steam pipe. Sodium carbonate solution is introduced into the tank and diluted with water until it registers from ½ to 2° Tw., according to the nature of the

goods to be treated. The handkerchiefs, in bundles of a convenient size, are then placed in the solution and the latter raised to the boiling point and kept at that temperature for about an hour. The goods are pushed beneath the surface of the liquor from time to time by means of a wooden pole, which is also used to lift the bundles from the tank so soon as the operators are ready to deal with them.

3. *Washing by Hand or Machine.*—This follows the scalding operation. If the goods are not too highly contaminated with foreign matter, both scalding and washing are completed in the rotary machine just as in the ordinary process of washing, but when the articles have been scalded in tanks, it is the usual custom to transfer them to porcelain washing troughs, in which the cleansing process is completed by hand, a good neutral soap being used for the purpose and the washing operation facilitated, if necessary, by the use of an ordinary rubbing board.

Goods which have been previously "printed" in black in order to "throw up" the embroidery do not need such a drastic treatment as other classes of hand embroideries. Indeed it is considered that the use of boiling alkaline solutions tends to remove too much of the colour, but the correctness of this statement is, of course, entirely dependent upon the nature of the colouring matter employed. One method of cleansing such goods, is to subject the embroidery parts to hand washing in suitable tanks or troughs, using a rubbing board, and then to complete the cleansing of the other parts by washing the goods in a rotary machine containing a little "alkali" and soap.

4. *Acid Treatment.*—It has been previously mentioned that, in many cases, the embroidery patterns are "printed" on the material to be embroidered with a greasy paste coloured with ultramarine blue, and since this colouring matter is practically unaffected by alkalies, it is obvious, that a greater or less amount will still be present on the embroideries after the completion of the washing process, inasmuch as the latter only effects the removal of the thickening agent. In order, therefore, to remove the last traces of blue, advantage is taken of the fact, that it is very sensitive in presence of comparatively weak acids, *i.e.*, it is readily decolourised and decomposed. Of the various acids which are suitable for the purpose, oxalic is generally preferred, because, apart from its action on ultramarine, it possesses the property of removing many of the iron stains with which the goods are frequently contaminated, and its use by operators who do not possess technical knowledge is much less dangerous, and does

not necessitate such close supervision, as when sulphuric or hydrochloric acid is employed.

The solution of the acid is contained in a small wooden tank or vat, into which the goods are subsequently introduced and allowed to remain in contact with the solution until all traces of blue and easily removable iron stains have disappeared. The strength of the solution should be about ½-1 oz. per gallon, and its temperature about 120° F.

5. *Dipping.*—The majority of hand embroideries are subjected to a bleaching or "dipping" process immediately after the oxalic acid treatment. It is carried out in a comparatively simple manner, the articles being merely steeped in a cold weak solution of "alkali dip" for a short time. The "dip" is contained in a wooden tank and its strength is regulated according to the nature and condition of the goods to be treated. The average strength, as indicated by the hydrometer, is from ½ to 1° Tw. As soon as the goods are white enough, they should be thoroughly washed in several changes of water.

It is not customary in the trade to use an acid after "dipping," but this practice is to be highly commended, especially in connection with the treatment of expensive articles. We have already given a detailed account of the principles underlying the "dipping" operation in a previous section of this work, so that we need not further deal with them here. It may be mentioned, however, that in a few laundries, warm sodium hypochlorite is commonly used in a separate bath to facilitate the cleansing process. Although, in such cases, care is usually taken to employ a very weak solution, it not infrequently happens, that the goods are tendered to a greater or less extent.

As already pointed out, the actual bleaching strength of "alkali dip" cannot be ascertained by means of a hydrometer, and, as the strength of the solution employed is rarely determined in a reliable manner by the launderer, it naturally follows, from a consideration of our previous remarks on the action of hypochlorites on cellulose, that the adoption of the warm steeping process is bound to give rise to serious defects sooner or later, and the method cannot be here recommended. Reference has been made above to the fact, that, in trade laundry work, the "souring" operation, *i.e.*, the acid treatment, usually precedes "dipping," and the reason for this has been given. It is questionable, however, whether this mode of procedure offers any advantages over the more scientific method of "dipping" first and "souring" afterwards, except in the case of goods contaminated with iron stains, and its more or less general adoption

in centres of trade laundry work, appears to be due to the opinion, that the last traces of blue used in printing the embroidery patterns must be removed before the goods can be uniformly whitened. If we carefully consider the statements made in a previous chapter concerning the use of hypochlorites for bleaching vegetable fibres, it will be at once apparent, that, when "dipping" is not followed by "souring," there is considerable danger of the fibres becoming tender or discoloured owing to the incomplete removal of the bleaching agent or its decomposition products. Again, it is to be noted, that goods which are intended for embroideries have been previously bleached, so that the paste used for "printing" the embroidery patterns falls on a clean white fabric, and, when dry, acts as an effectual resist towards dirt and other impurities. This paste is subsequently removed by washing, leaving a greater or less amount of colouring matter, *e.g.*, ultramarine blue, but the latter acts as a resist and in this way the "printed" parts of the fabric remain practically unsoiled except for the presence of the blue. If the goods are immediately "dipped" after the washing process, therefore, and then "soured," a clean white fabric is obtained which leaves nothing to be desired in the matter of uniformity of colour, and the articles exhibit less tendency to develop tenderness or other defects on storing. Less water is also required for rinsing purposes after each operation than in the usual system. On the other hand, goods which are stained with iron are best treated according to the former method, as such stains become more fully oxidised if the goods are first brought into contact with sodium hypochlorite, and in many cases, the stained parts of the articles are completely rotted.

Finishing.—The finishing of handkerchiefs is carried on in a comparatively simple manner, and does not necessitate the employment of elaborate mechanical appliances. As a general rule, little or no starch is used, since the chief object of the finisher is to produce an article possessing a soft "handle" and exhibiting lustre only to a very small extent. The operations are as follows:—1. Blueing and starching. 2. Squeezing or hydro-extracting. 3. Ironing and folding.

1. *Blueing and Starching.*—These operations take place immediately after "dipping" and "souring." The blue water only, or blue water and starch as the case may be, are contained in a wooden tank, and the temperature of the liquor is kept at about hand heat. The handkerchiefs—both plain and embroidered—are simply agitated by hand in the liquid for a few seconds and then removed and squeezed or hydro-extracted. For a dull "finish" no starch is employed, but when a slight gloss is re-

quired and a somewhat fuller "handle" the following mixture may be used:—

Finishing Paste for Handkerchiefs.

3 pints starch paste (1 lb. to gallon).
3 gallons water.
1½ lbs. "finish."
1 gill oleine, *i.e.*, Turkey red oil.

The "finish" referred to in the above recipe is one of the numerous proprietary soap "finishes," which are sold for the purpose. A good quality of curd soap and a little glycerine may be used instead. The proportions given can be easily altered according to the results desired, while the oleine may be omitted if considered objectionable. Sufficient blue is added to give the desired tint to the goods, ultramarine being usually employed, as it is considered that this blue yields the most satisfactory results, especially when the goods have to be stored for a considerable length of time.

2. *Squeezing or Hydro-Extracting.*—After blueing, and—if necessary—starching, the goods are removed from the tank and squeezed or hydro-extracted. Squeezing by means of a machine similar to that illustrated on page 145 is largely practised, while the hydro-extractor only finds a limited use in this branch of the industry. When the squeezing machine is employed, it should be provided with rollers covered with woollen material or preferably rubber, and the pressure should be regulated according to the amount of moisture to be retained by the goods. From half to one dozen handkerchiefs—folded carefully—may be passed between the rollers at a time, after which operation they are ready to be taken in hand by the ironers.

3. *Ironing and Folding.*—All classes of handkerchiefs are generally ironed by hand. The back is ironed first and then the face. Embroidered goods are ironed over the whole of the backs, but, in most cases, only over the plain parts of the right sides, this plan being of great service in preserving the raised appearance of the embroidery effects. Folding is conducted as the ironing proceeds,

Bedspreads, Sheets, Robes, Blouses, etc.—The operations involved in the cleansing of other classes of newly manufactured detached articles are practically identical with those just described in connection with the treatment of handkerchiefs, although open boiling tanks are seldom employed. The mode of procedure actually adopted is dependent upon the nature of the articles, *i.e.*, whether they are plain or embroidered, and is largely influenced by their condition, which latter is, of course, dependent upon the

kind of treatment to which they have been subjected during the manufacturing operations. The impurities associated with hand embroideries usually offer a considerable amount of resistance towards the detergents employed, but other classes of goods are cleansed without much difficulty and need not be further considered. The simplest process for the treatment of the former is carried on in the ordinary washing machine. Another process involves the use of a machine in which the goods can be boiled under a steam pressure of a few pounds, while a third process includes a preliminary steeping operation in a solution of a weak acid. The second process appears to give the most satisfactory results, and it occupies less time than the former. A typical example is given below:—

Example:—

1. Breakdown, using lukewarm water in pressure machine for 10 minutes.
2. Second breakdown, using warm water and 1·2 gallons stock soda solution for 10 minutes.
3. First suds. Use 3-6 gallons stock soda solution and 1·2 gallons stock soap solution. Raise temperature of liquor gradually to boiling point in about 25 minutes. Remove liquor.
4. Second suds. Use 4 gallons stock soda solution and 2 gallons stock soap solution. Raise liquor to boil and boil under a few pounds pressure for half an-hour. Remove liquor.
5. Rinse for 5-6 minutes in hot water.
6. Rinse for 5 minutes in cold water.

For very dirty goods, stronger liquors are used, and the above operations carried on for longer periods of time.

When the ordinary type of rotary washing machine is employed, the cleansing process frequently occupies from two to four hours according to the condition of the goods, but, apart from the fact that weaker detergents are usually employed, this treatment is certainly more drastic than that carried on in a pressure machine.

The third process differs only from the foregoing in that the first operation consists of a treatment with weak cold acid or "sours"; it is practised to a considerable extent in centres of the embroidery industry, especially on the continent. It is interesting to note, that weak acids have long been used in the preliminary treatment of goods heavily charged with impurities, although the action or actions involved are not fully understood. Starchy matter is converted more or less completely into soluble substances; metallic oxides are dissolved, and metallic soaps decomposed, while other impurities appear to be modified to a greater or less extent.

In practice, the treatment is carried on by steeping the goods overnight in weak cold sulphuric acid, usually about ½°-1° Tw.

They are then thoroughly rinsed in cold water, and subsequently washed in ordinary machines according to the usual methods.

Oxalic Acid Treatment and "Dipping."—These operations are identical with those already described in connection with the treatment of handkerchiefs. Practically the same remarks apply in both cases.

Finishing.—Large detached articles, both plain and embroidered, are finished in much the same way as handkerchiefs. The "finish" usually imparted is characterised by the exhibition of a comparatively small amount of lustre, and the goods possess a soft handle, as well as a greater or less amount of "body." A high degree of lustre is not often required. Cotton articles are frequently finished in such a way as to cause them to possess a somewhat stiffer "handle" than similar articles made of linen, but even in such cases, only a slight amount of lustre is desirable.

Ordinary maize starch is usually employed. It is boiled up with water in a suitable vessel, and the paste obtained passed through a calico strainer into the starching apparatus. The latter merely consists of a wooden tank or tub provided with a steam pipe. Varying amounts of one of the proprietary pastes sold under the names of "finishes," softeners," etc., are added to the starch according to requirements, as is also sufficient blue to neutralise the yellowish tint of the fibres. Starching is carried on by hand, the goods being rubbed and agitated in the mixture for a short time. They are then removed; wrung by hand, and passed through a power wringer, the rollers of which are covered either with flannel or rubber. Finally; they are shaken out, and are then ready for ironing. The latter operation is generally done by hand. In the case of large embroidered articles, such as bed-spreads, robes, etc., it is customary first to iron over the right side including the embroidery, and to finish on the wrong side, so as to raise the embroidery effects. Fairly heavy irons are used, and two operators—one at each side of a double table—frequently work at the same article. After ironing, the goods are aired, and subsequently folded and packed.

The treatment of other articles included in this section does not call for any special notice. In most cases, the operations involved are identical with those described in previous paragraphs.

Valuable articles should be washed and finished entirely by hand.

CHAPTER IV.

Institution Laundry Work.

In most of the great public institutions, such as hospitals, workhouses, and asylums, it is essential to provide efficient means for the rapid cleansing of wearing apparel and other articles supplied for the use of inmates. In addition, there is usually a considerable amount of work to be done for the resident staff, so that the establishment of a steam laundry for coping with work of this nature is one of the chief features for which provision is made in the planning and equipment of such institutions.

As a general rule, the operations involved are not unlike those which have already been described in the chapter devoted to domestic laundering. Most of the articles, however, are simply washed and dried, starching operations only being required for the purpose of re-dressing some of the articles used by the staff.

It is not intended here to give particulars of the methods of washing adopted for the different classes of goods, since such a course would involve a repetition of the details given in the examples of washing processes in Chapter I., Part II.

The washing machines usually employed in hospitals and workhouses are similar to the all-metal machines commonly used in commercial laundries, although many authorities appear to favour those of the pressure type for general work.

In asylums, all-metal machines are also in general use, but, as some of the inmates assist in the washing operations, it is customary to enclose completely all readily accessible and dangerous mechanism by means of special gear cases.

A typical pair of machines built on this principle, fixed in position, and connected with the necessary steam and water supply pipes is shown in Fig. 132. The arrangement is very compact, and the machines are more or less self-contained. A noticeable feature is the provision of external bearings for the inner cylinder, thus enabling the parts to be easily overhauled. The gear cases are clearly shown in the figure, from which it will be also noticed that the machines are of the under-driven type. Smaller doors than those usually provided for commercial washing machines are recommended.

Washing in Troughs.—The cleansing of a considerable number of articles by hand is still a feature of laundering operations carried on in institutions, just as it is in ordinary trade domestic

laundering. Such work is commonly conducted in wash-troughs, of which many compact arrangements are available. They are usually made of porcelain, or wood, and, apart from their specific

FIG. 132.—ROTARY WASHERS FOR ASYLUM USE.
(*J. Braithwaite and Son, Ltd.*).

use, are of general utility in the average laundry. A neat arrangement with hot and cold water supply pipes is shown in Fig. 133. It is suitable either for institution or commercial laundries.

Foul "Linen" Washing.—For the purpose of cleansing articles which have been fouled by helpless patients, special types of machines—known as "foul-washers"—are built by different makers. They are so designed as to obviate as little handling of the goods as possible, while all noxious matter is carried away to the drains automatically. The old plan of cleansing foul "linen" consisted in spreading the articles on an open grating and directing a stream of water upon them by means of a hose pipe. This practice necessitated a certain amount of handling,

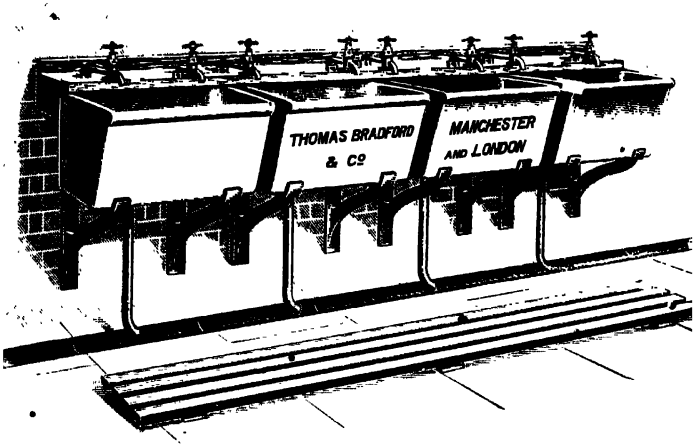


FIG. 133.—WASH TROUGHS.

and was very unsatisfactory in many ways. With the introduction of "foul-washers," however, a more rational system was rendered possible, and there is now no necessity to touch the goods after they have been introduced into the machine, until they are perfectly clean

One form of foul-washer is shown in Fig. 134. It consists of a brass cylinder riveted to flanged ends lined with brass, and provided with a steam-tight door of the same material. The cylinder is carried by hollow shafts or trunnions—fitted with glands and stuffing boxes—working in suitable bearings in the cast-iron end pieces. Water, steam, soap liquor, soda, etc., are

injected through the shaft at one end of the machine and enter the cylinder through the perforations in a series of hollow brass rubbers. The impurities from the "linen" float to the top and are carried away through the hollow shaft at the other end of the machine, which is fitted with a syphon trap for connecting to a drain, thus preventing the escape of noxious fumes into the wash house. The usual valves, and reversing and locking gear are provided, while a guard plate with a hinged flap is fitted to the front of the machine. This flap prevents articles from falling

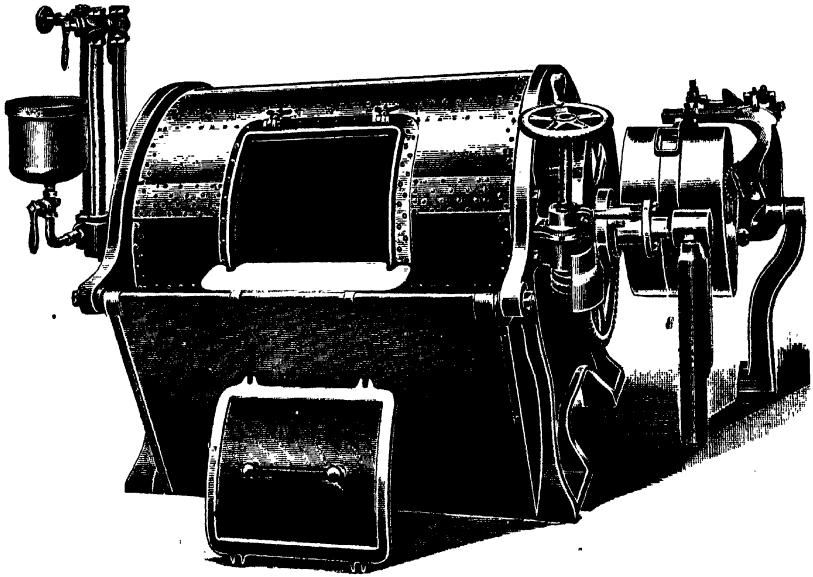


FIG. 134.—FOUL "LINEN" WASHER.
(Cherry Tree Machine Co., Ltd.).

between the plate and cylinder during loading or unloading. Other attachments include a special mixing chamber and a copper container for introducing soap, water, etc., into the machine whenever required.

Fig. 135 illustrates a type of foul-washer made by Manlove, Alliott and Co., Ltd. In general appearance it resembles the ordinary form of rotary washer; its chief distinguishing feature, however, is the provision of an automatic flushing arrangement, consisting of a ball cock at one end of the machine and a syphon

pipe at the other end. The syphon is so arranged, that the waste water is spread fan-wise, and thus admits of its condition being noticed while discharging. The mode of working is as follows:—The goods are placed in the machine in their fouled state, and, if considered desirable, a little soap and disinfectant are added. The machine is then closed and set in motion. As the cylinder revolves, it is automatically flooded with cold water from the flushing cistern, until the level of the syphon is reached; at this stage, the latter rapidly and completely empties all the water from the machine and sweeps out sediment from the casing. The first flush is of a very dirty character, and it is maintained that this flush takes away nine-tenths of the foul matter with which the

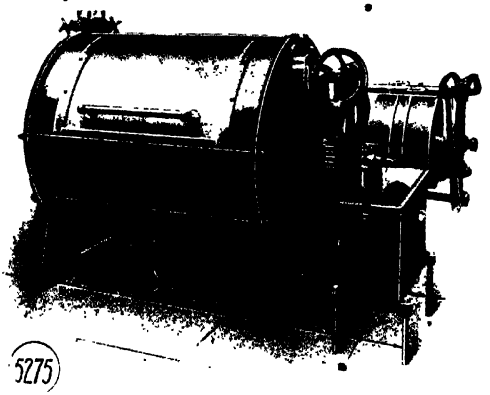


FIG. 135.—FOUL "LINEN" WASHER.
(*Manlove, Alliott and Co., Ltd.*).

goods are contaminated. The machine floods and flushes again. After three flushings, the articles are quite free from foul matter, and are ready to be removed. The time occupied is about forty minutes, and the action is entirely automatic, so that no attention whatever is necessary after starting the machine until it requires emptying. The advantages claimed for this system are:—1. The machine is completely emptied of water by each flush, so that the bulk of the foul matter is removed very quickly. 2. The machine casing is not liable to become fouled, and 3. Cold water is used, since it readily absorbs ammoniacal gases, etc., whereas hot water liberates them.

Finishing.—The finishing operations carried on in institution laundries are, as a rule, of an exceedingly simple nature. The

largest proportion of the goods is of the "flat work" description and is either rough dried only, or dried and ironed by means of a decoudun. During the last few years, considerable use has been made of multiple ironing machines for the general work of institutions, as it is found that such appliances are well adapted for rapidly drying and ironing all flat articles which have not been starched. In the absence of a decoudun or multiple ironer, practically all ironing is done by hand, this mode of procedure being also commonly adopted for finishing the starched articles used by the staff, although in well equipped establishments a more or less complete ironing plant is available for the purpose.

The best modern practice in designing and equipping institution laundries, consists in the division of the laundry department into two sections, one of which contains plant specially adapted for the general work of the establishment, and the other, all necessary machines for the efficient treatment of the articles of wear, etc., belonging to, or provided for the staff. These machines are, of course, similar to those used in ordinary laundering practice.

Disinfection.—Although the disinfection of textiles is not widely recognised as a branch of the laundering industry, nevertheless, the fact that in a large number of cases—especially in institution work—it constitutes the first operation in the cleansing process, necessitates the inclusion here of a short account of the chief methods in vogue.

All patients in public institutions who are found to be suffering from infectious diseases are immediately isolated, and the clothing, bedding, and other articles which have been used by, or come into contact with them, subjected to a thorough disinfecting process as soon as possible after the disease or diseases have been diagnosed. In mild cases, cotton and linen articles may be steeped in a liquid disinfectant—usually carbolic acid, or sodium hypochlorite,—and subsequently washed in a rotary pressure machine, but blankets, and other woollen articles, mattresses, etc., are best treated in one of the steam disinfectors specially designed to accomplish the chief object in view without injuriously affecting the physical properties of the goods.

It is now customary to treat all patients suffering from infectious diseases at isolation hospitals, but it not infrequently happens that patients in ordinary hospitals develop malignant symptoms, which call for prompt action on the part of the authorities in order to prevent an epidemic. In workhouses, similar cases, as well as others, arise from time to time, so that suitable provision for the effective treatment of all suspected goods is of the utmost importance.

A disease is said to be infectious when it is caused by minute living organisms known to bacteriologists as pathogenic microbes. The principal infectious diseases which most frequently cause epidemics are as follows:—Enteric (typhoid) fever; smallpox; scarlet fever; diphtheria; measles and whooping cough. Of these, the first four are compulsorily notifiable to the sanitary authorities, so that suitable measures may be immediately taken to prevent contagion. Many other infectious diseases are known, some of which are compulsorily notifiable, but they do not often give rise to serious epidemics.

A few commercial laundries are in existence, in which a speciality is made of the disinfection and cleansing of all kinds of textile articles suspected of harbouring infectious matter, but the usual custom is to carry on such work in public institutions, the goods being subjected to the action of steam in specially constructed disinfectors, and, in some cases, cleansed afterwards in rotary washing machines. The latter operation is, of course, chiefly suitable for cotton and linen articles.

In addition to the class of microbes mentioned above, there is another kind known as non-pathogenic microbes. These appear to be incapable of producing disease, although many of them certainly possess the property of inducing the putrefaction of organic matter. The term *disinfection* is used to indicate an operation which has for its primary object the destruction of pathogenic microbes, while the term *sterilization* is used when the object is to cause the death of all organisms whether capable of producing disease or not.

A great deal of time has been devoted by many eminent bacteriologists to the study of the best means of effecting the destruction of disease producing microbes, and it would appear from the results of innumerable experiments, that the simplest method of achieving this result is to subject the infected goods to the action of a current of steam for a comparatively short period of time.

Steeping in solutions of certain chemical reagents, *e.g.*, sodium or calcium hypochlorite, coal-tar derivatives, mercuric chloride, permanganate of potash, etc., or exposure to the action of sulphide dioxide gas is also practised to a considerable extent, but the majority of isolation hospitals, and other institutions, as well as those commercial laundries in which a speciality is made of the disinfection of goods for the public, and various local authorities are equipped with steam disinfectors. These offer many advantages compared with liquid disinfectants, among which may be mentioned their compactness, rapidity and certainty

of action, and the ease with which they can be isolated from all parts of the establishment. In many hospitals, sodium hypochlorite, prepared electrolytically from brine, is sometimes employed for the preliminary treatment of various classes of cotton and linen goods, so that bleaching and disinfection take place concurrently.

The employment of liquid disinfectants in this way, however, is accompanied by various drawbacks. In the first place, the process is not suitable for all classes of goods, and in some cases needs to be followed by an additional chemical treatment besides the usual rinsing or washing operation. Secondly, a considerable amount of space is taken up by the tanks containing the disinfectants, *i.e.*, provided a steeping process in tanks is adopted, while in the third place, most of the liquids advocated are either of a highly poisonous nature or exert a detrimental action on many fibrous materials under suitable conditions. Furthermore, the complete destruction of pathogenic microbes by means of liquid disinfectants at the ordinary temperature, is dependent upon (*a*), the resisting powers of the different germs towards the particular disinfectant used; (*b*), the strength of the disinfectant and its physical condition; and (*c*), the length of time the goods are in intimate contact with it.

It is thus evident, that the physical condition of the disinfectant employed, as well as time and strength factors need very careful attention, if the steeping process is to achieve those results for which it is frequently advocated.

H. Püsch has shown that a solution of sodium hypochlorite (prepared electrolytically by means of the Haas and Oettel apparatus), containing 17 grains of active chlorine per gallon absolutely kills all typhus germs in 15 minutes, although solutions of 13, 10, and 2 grains strength have apparently little disinfective action. Similarly, anthrax spores were destroyed within 24 hours by means of a solution containing 35 grains of active chlorine per gallon, but the same result was obtained in 2 hours by steeping in mercuric chloride solution of the same strength. Even a solution of sodium hypochlorite of a strength of 350 grains active chlorine per gallon failed to destroy all anthrax germs in two hours.

According to Nesfield (*Lancet*, 1908, *p.* 1708), the presence of 8.75 grains active chlorine per gallon of water teeming with *B. typhosus*, *B. coli*, etc., is sufficient to sterilise it in five minutes.

Mercuric chloride solution is usually regarded as the most powerful of all liquid disinfectants, although many authorities

consider formaldehyde to be quite as effective. According to Woodhead the minimum strength of the former for disinfection should be 1 in 500, the intensity of its action being increased by the addition of ½ per cent. of hydrochloric acid. It is highly poisonous and cannot be used in conjunction with soap.

The usual working strength of formaldehyde is 1-2 per cent., but it is said that a ½ per cent. solution kills most organisms.

Carbolic acid and a large number of proprietary coal-tar disinfectants are used to a considerable extent for the disinfection of textile goods. Most of these contain carbolic acid (phenol) and allied substances (phenoloids) in greater or less amount. They may be divided into two groups, viz.: Those forming emulsions with water and those which yield clear aqueous solutions. The germicidal value—in terms of the *Lancet Carbolic Acid Coefficient*—and the chief data obtained by the chemical examination of members of both groups are included in the following table (*Lancet*, ii., 1909):—

PERCENTAGES OF PHENOL OR PHENOLOIDS IN VARIOUS PROPRIETARY COAL-TAR DISINFECTANTS, AND THEIR CARBOLIC ACID COEFFICIENTS.

Disinfectants forming Emulsions with Water.	Hypothetical Phenol Content by Bromine.	Percentage of Phenols or Phenoloids.	*Lancet* Carbolic Acid Coefficient.
Cofectant	38·30	66·27	9·8
Sanitas Bactox	19·30	39·70	9·5
,, Okol	27·44	48·50	8·9
Cyllin ('bulk')	24·16	40·41	8·8
McDougall's M.O.H. Fluid	22·71	47·13	7·9
Kerol	17·23	40·56	7·7
Izal	27·48	41·35	7·4
Cyllin, Medical	12·79	32·08	6·4
Pearson's Antiseptic Fluid	12·73	20·70	2·2
Jeyes' (Chemists)	11·50	17·80	1·7
Lawes'	18·08	28·20	1·6
Zotal	6·70	10·00	1·5
Krysyl	9·87	14·16	1·3
Jeyes' No. 2	1·87	5·13	0·75
Disinfectants yielding Clear Aqueous Solutions.			
Crude Carbolic Acid	61·65	82·65	4·2
Calvert's No. 5 Carbolic Acid	74·09	93·26	2·5
Trikresol	—	—	2·5
Lysol	40·45	50·96	1·7

In the chemical examination of the above, fatty acids, resins, and neutral oils were precipitated by means of baryta, while

acetone was employed for washing out all traces of the oils. The phenol content was determined by bromine absorption, and the proportion of phenoloids by weight. In most cases (see table), the latter figure was considerably higher than that for carbolic acid, and it was found that the wider the discrepancy, the greater the germicidal powers. As a result of the figures obtained, it is concluded that coal tar disinfectants should contain a reasonable amount of phenols and phenoloids, and that they should exhibit Brownian movement in presence of water, *i.e.*, they should be capable of forming proper emulsions. It was found that, by subtracting the carbolic acid value from the phenoloid content in each case, the figures obtained gave results corresponding—in most cases—with the bacteriological germicidal values. On dividing these results by 3, the figures obtained were found to coincide with the carbolic acid coefficient (using *B. coli*).

It is important to note that the figure for any particular disinfectant varies for different organisms. For further information on this subject, the reader is referred to *The Report of the Lancet Commission on Disinfectants.*

From a consideration of the results recorded in a previous paragraph, it is evident that the complete destruction of all pathogenic organisms by means of liquid disinfectants can only be accomplished by steeping the goods in a comparatively strong solution for a considerable length of time. It is generally agreed by those authorities who have studied the matter, that the ordinary washing processes carried on in rotary machines, particularly those of the pressure type, in conjunction with soap, exert a powerful destructive action on all living organisms, and it is obvious that the danger of goods so treated carrying infection, is still further diminished if they are given a final treatment with a solution of a suitable disinfectant, such as a hypochlorite—provided the goods are of vegetable origin and free from colour effects—or a phenoloid substance, mercuric chloride, formaldehyde, etc.

This practice is an excellent one, and, when the first mentioned substance is employed, is well adapted for cleansing, disinfecting, and whitening the majority of those articles of cotton and linen which may be suspected of harbouring infectious matter.

A preliminary treatment of goods contaminated with impurities, with disinfectants that act by oxidation, is inadvisable, however, since many of the impurities, stains, etc., may become so altered as to render their subsequent removal a matter of considerable difficulty.

For the general work of isolation hospitals, as well as for occasional work in other institutions, it is difficult to conceive of

a more satisfactory and reliable method of disinfection than that which depends upon the use of steam.

As pointed out above, the pressure washing machine, which may be termed a low pressure disinfector—can only be used for cotton and linen goods, but disinfectors in which the goods remain stationary during treatment and in which steam only is used are eminently adapted for handling goods made from all kinds of fibrous materials, without affecting them injuriously.

Experiments have shown that all known pathogenic germs are destroyed by steam under a pressure of about 5 lbs. in from 15-30 minutes, according to the facility with which penetration takes place, while if the temperature is not allowed to exceed about 120-125° C., practically all fibrous materials may be safely treated without suffering any apparent deterioration in physical properties. Many types of steam disinfectors have been introduced, the majority of the older forms having been designed for use with confined steam. In the best known modern machines, however, a current of steam is employed, these being termed current steam disinfectors. In other types of machines auxiliary means are employed for the purpose of removing air, so as to facilitate the penetration of the goods by steam. One method of accomplishing this result is by producing a partial vacuum by means of an air pump or an ejector, while a simpler plan is to allow the steam to reach the desired pressure, and then to allow it to escape through a suitable outlet valve. The latter is then closed and the process repeated several times according to the thickness of the articles undergoing treatment.

The advantages claimed for machines working with current steam are as follows:—1. The machines are simple in construction. 2. They are easy to work, the removal of air being rendered automatic by means of a rapid current of steam, this effect having been demonstrated by Delépine. 3. They are free from the dangers associated with machines to which confined steam is used. 4. The goods are readily dried in the apparatus after they have been disinfected.

It would appear therefore that, by the use of a current steam machine, thorough disinfection is ensured in a comparatively simple manner. One objection frequently put forward against the use of steam disinfectors is that many of the impurities with which certain classes of goods are often contaminated are modified by the heat in such a way that their subsequent removal in the laundry is a matter of considerable difficulty. With the exception of blood and other stains of an albuminous nature, however, this statement appears to be indefensible, for it seldom hap-

pens that the ordinary impurities usually met with on steam disinfected cotton and linen articles are capable of withstanding a washing process in a pressure machine, while woollen goods are readily treated by hand. Blood stains, however, usually leave yellowish marks after washing, owing to the presence of iron and coagulated albumen. As a rule, a short immersion in weak oxalic acid suffices to remove them, although in some cases the application of a mild bleaching agent—suitable for the particular fibre to be dealt with—is necessary. Another objection against the use of the machines in which the goods become wet is that articles containing colour effects are badly stained owing to the colours "running" or "bleeding" into other parts of the materials.

Current Steam Disinfectors.—The use of current steam constitutes one of the chief features of the well known disinfectors made by the Thresh Disinfector Co., to whom the credit of demonstrating its great value for disinfecting purposes is largely due. The Thresh apparatus is built in different sizes and in various forms. In the simplest form—which works at atmospheric pressure—the steam is generated in the jacket of the disinfector from a solution of potassium carbonate of such a density as will give a boiling point of 215° F. This type is generally heated by means of a furnace set in brickwork upon which the disinfector rests. High pressure steam—if available—can be used for heating purposes, the potassium carbonate solution being raised to boiling point by passing the steam through a series of copper coils fitted in the jacket of the disinfector. The advantages claimed for the use of potassium carbonate solution in the jacket are as follows:—

1. Prevention of undue wetting of the goods during disinfection by heating the chamber slightly above the condensing point of steam at atmospheric pressure.

2. The temperature of the air used for drying after disinfection is raised.

3. Incrustation is prevented from forming in the jacket of disinfector.

Infected goods are placed in a galvanized iron basket which travels on rails into the previously heated chamber; the door is then closed and the goods subjected to the action of current steam for a greater or less length of time according to their nature and condition. After disinfection is completed, hot air is introduced at the bottom of the machine for drying purposes. Many articles are then washed in rotary machines. A modified form of the above

type of disinfector has been introduced, in the jacket of which, steam is used instead of potassium carbonate solution. It may be heated by means of a furnace, or high pressure steam from a boiler as in the original machine. In the latter case a suitable reducing valve is used to obtain a comparatively low pressure before the steam is introduced into the chamber, the actual pressure in the latter after working for some time being about 3 lbs., while that in the jacket is regulated to about 4 lbs. by means of a dead weight safety valve. In this machine (Fig. 136) a temperature exceeding 212° F. is obtained by using steam at a pressure a little above that of the atmosphere. Thus, the volume of steam passed

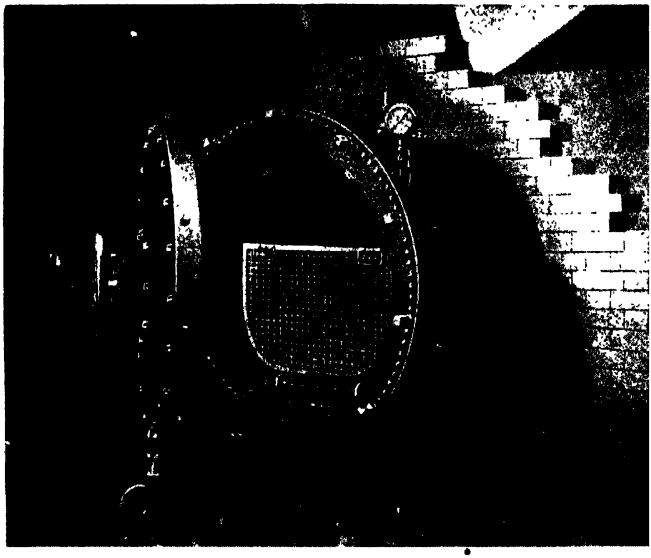


FIG. 136.—CURRENT STEAM DISINFECTOR. LOW PRESSURE TYPE.
(Thresh's Disinfector Co., Ltd.).

through the chamber in a given time is increased. The steam is introduced into the disinfecting chamber at the top, and readily displaces the heavier air, thus ensuring rapid penetration, while condensed steam is removed through an outlet pipe communicating with a steam trap. The goods are subsequently dried by means of a current of hot air, a steam jet being used at the outlet (top of chamber) for inducing a rapid current.

The *Delépine-Jones Patent Current Pressure Steam Disinfector.*—It is preferable, in many cases, to employ steam under a considerable amount of pressure for disinfecting purposes, especially for the destruction of certain spore-bearing organisms which offer great resistance towards the action of heat; also in cases where thick articles such as mattresses, etc., containing considerable quantities of air, need to be treated. A machine specially designed for such work is shown in Fig. 137. It is suitable for use with steam under a pressure of 20 lbs. or less, and as in other types of two-door disinfectors it is customary to separate the front or "infected" end from the exit of "disinfected"

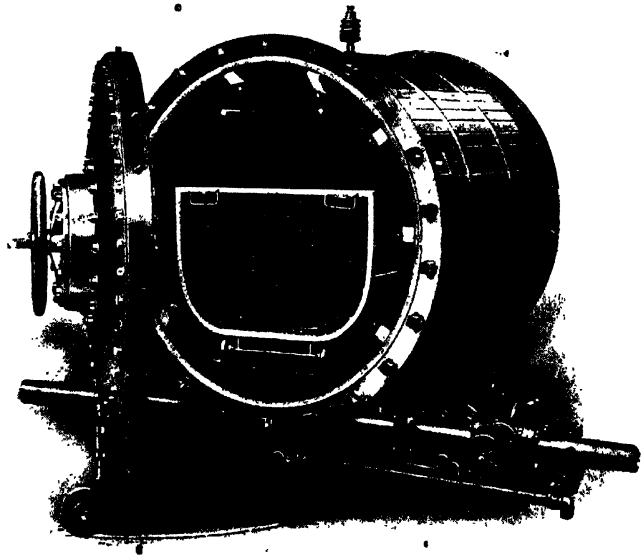


FIG. 137.—CURRENT PRESSURE STEAM DISINFECTOR. "INFECTED" END.
(*Thresh's Disinfector Co., Ltd.*).

end of the machine by means of a suitable partition—usually a brick wall—extending to the top of the room, thus affording ample protection against the danger of the disinfected goods being re-infected. It is claimed, that the most highly-resistant spore-bearing germs are completely destroyed by the use of this machine, and that the mode of working is characterised by great simplicity when compared with other high pressure disinfectors.

The machine consists of an outer shell of steel, lined with a continuous close coil of steam tubing. Pressure steam from the boiler passes through this coil, and is admitted into the disinfecting chamber by a perforated pipe which lies on the bottom of the coil. The perforations are so arranged that the steam entering the chamber impinges on the coil. Superheating is impossible, as the steam, which is condensed upon entering the disinfector is rapidly re-evaporated and remains saturated.

For drying purposes an inner lining is provided, causing the air which is admitted at one end of the machine to travel over the coil containing pressure steam before it obtains access—at the opposite end—to the disinfecting chamber proper. The steam in the chamber is retained at any required pressure by means of a loaded valve on the outlet, and so long as steam is issuing freely from this valve, the operator knows that disinfection is proceeding satisfactorily. A continuous current of steam at any desired pressure up to 20 lbs., can be maintained by regulating the load on the outlet valve, the steam pressure at the inlet being immaterial, so long as it exceeds that at which it is desired to conduct the disinfecting process. At the conclusion of the latter, the air inlet valve is opened, and—by means of a steam jet in conjunction with the steam coil—a rapid current of hot air is drawn through the chamber, and the articles contained therein are quickly dried.

The doors of the machine are of special design, and are opened or closed by merely turning a central hand-wheel, thus dispensing with the use of a series of independent screw clamps. This arrangement renders it very difficult for the door to be opened whilst steam pressure remains in the chamber. A plan of a suitable building, with a two-door disinfector placed in position is shown in Fig. 138. The conclusions arrived at by Sims-Woodhead after conducting a number of careful experiments with the Delépine-Jones' machine are as follows:—

1. The disinfector is simple to work.
2. Its sterilizing power is highly efficient.
3. Moisture is readily driven off the sterilized articles.

That the machine possesses highly efficient sterilizing power is evident from the experimental results, which show that it readily kills not only the *bacillus diphtheriæ* and the *staphylococcus pyogencs aureus*, but the resistant spores of the disease-producing *anthrax baccillus*, and the still more highly resistant spores obtained from stable manure as well as spores embedded in the actual manure and in earth.

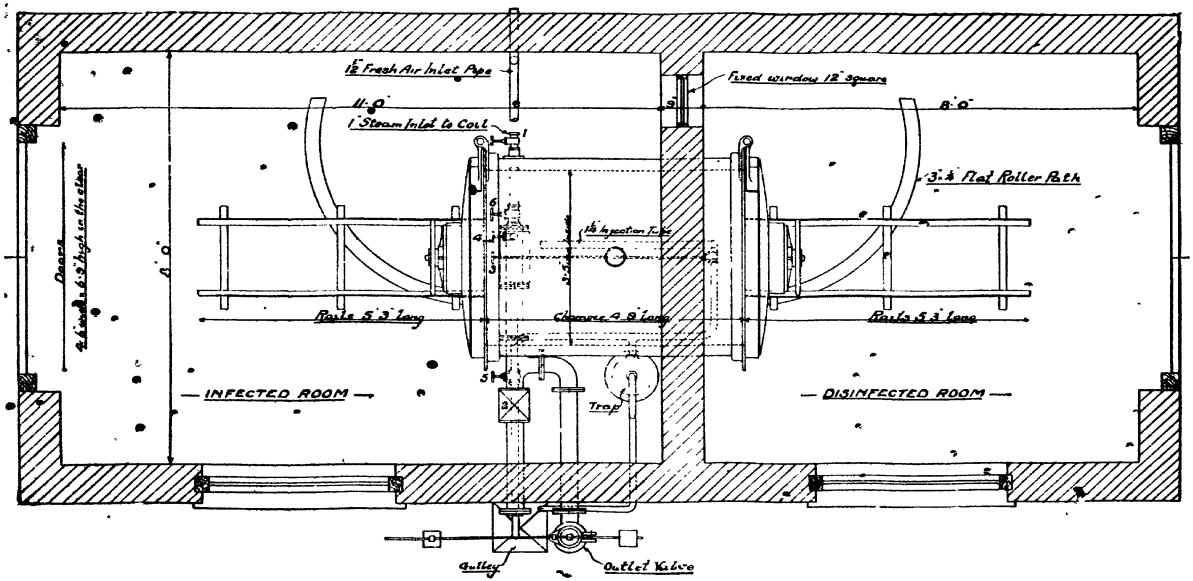


FIG. 138.—PLAN OF BUILDING FOR DOUBLE-DOOR DISINFECTOR.

(Thresh's Disinfector Co., Ltd.).

In operation, the articles to be disinfected are placed in the basket provided or on hooks at the receiving end of the machine.

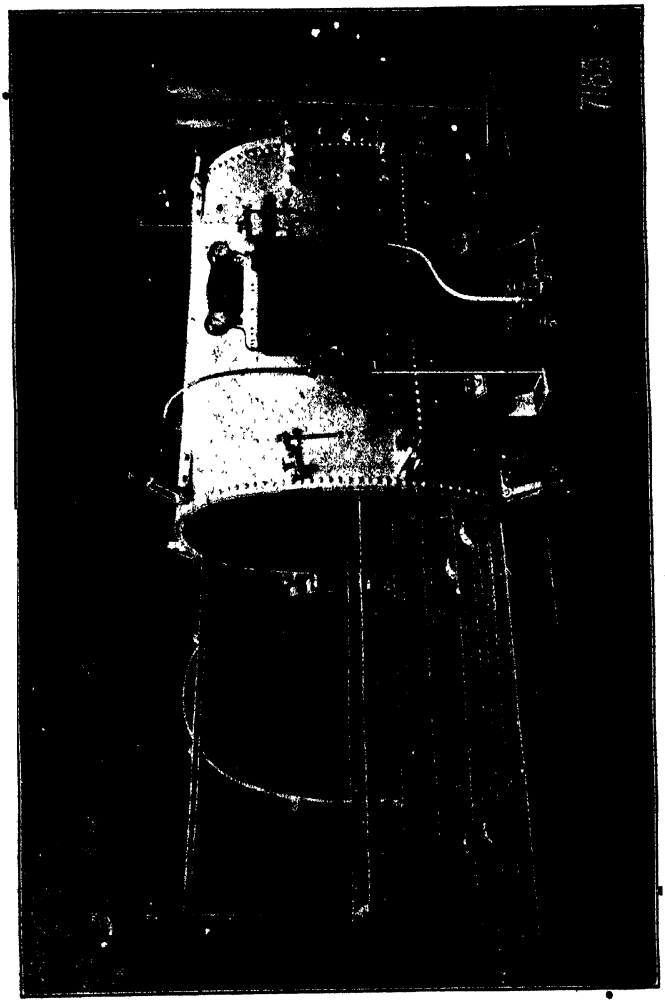


FIG. 139.—ALLIOTT AND PATON DISINFECTOR.
Manlove, Alliott and Co., Ltd.).

The door is then closed, steam turned on at the proper pressure and the action allowed to continue for the requisite period of

time; the latter is, of course, largely dependent on the kind of work in hand. At the conclusion of the operation, the steam is shut off, and the air inlet valve opened, whereby a rapid current of air is drawn through the chamber and the articles thoroughly dried. Finally, the door at the "disinfected" end is opened and the goods removed.

The Alliott and Paton Disinfector.—Another well known type of disinfector working with high pressure steam is shown in Fig. 139. It is built by Messrs. Manlove, Alliott, and Co., Ltd., and is an improved form of the original Washington Lyon apparatus. Its chief distinguishing feature, compared with the machines already described, is the provision of apparatus for creating a partial vacuum in the disinfecting chamber, so that the goods are directly and thoroughly penetrated by steam or hot air as the case may be, which is subsequently admitted, while the last traces of steam can be removed from the goods by the same means. The machine consists essentially of a jacketed chamber with a door at each end. Steam is admitted to the jacket at a higher pressure and consequently at a higher temperature than that admitted into the inner chamber, thus preventing condensation on the inner walls of the apparatus. Fittings for the control of the steam supply and pressure are provided, together with an air pump for producing a partial vacuum. Also apparatus for heating the air supply and for ensuring that the steam admitted into the chamber is in the condition known as "dry saturated," *i.e.*, steam in contact with the water from which it is generated, but free from particles of unvapourised water. A truck is arranged to run on rails from the receiving or "infected" apartment into the machine, and from thence into the delivery or "disinfected" apartment. All fittings connected with the jacket are placed on the left hand and all chamber valves, etc., to the right. Among other advantages claimed for the machines, the following may be mentioned:—

1. Employment of a vacuum producing apparatus in order to facilitate the immediate and thorough penetration of the goods by steam or hot air as required.
2. Use of high pressure dry saturated steam without wetting the goods.
3. Coloured patterns on the most delicate fabrics are not injured, and the colours do not "run."
4. Machine can be used for the hot air disinfection of furs, leather, or other articles liable to be injured by steam. In this case the use of a vacuum ap-

5. The fittings, although few in number, and quite simple, are so arranged that the apparatus can be used in a variety of ways. For example:—

As a simple hot air oven, with a current of hot air; as a low or high pressure steam disinfector, as a low or high pressure current steam machine; hot air can be used *to warm* the goods before turning on steam to disinfect, and it can *also be used to* "air" the goods after disinfection, etc., etc.

A rectangular type of machine is built for disinfecting bales of goods and other bulky articles, while a third form is portable, with self-contained boiler and furnace.